POWER

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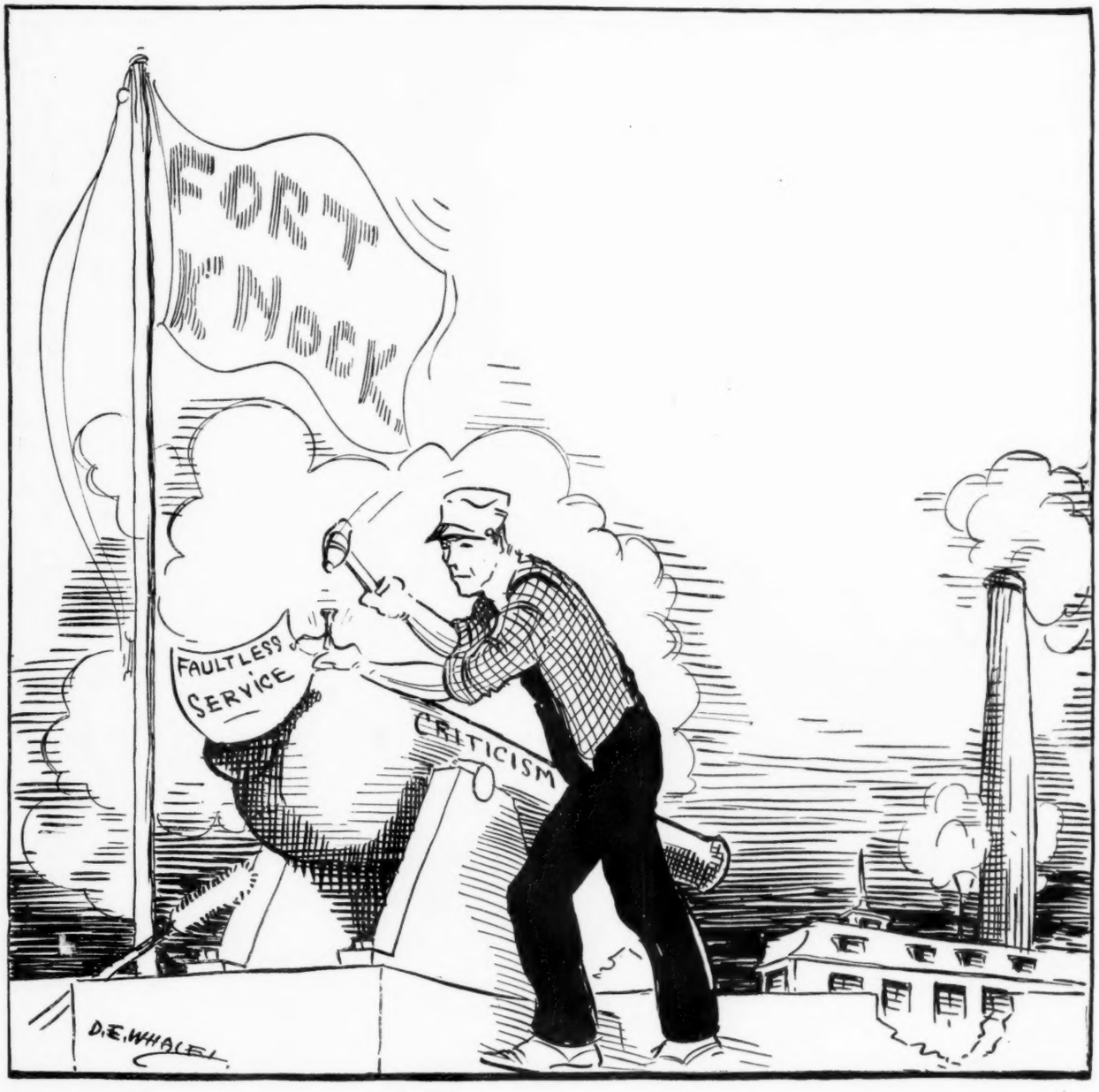
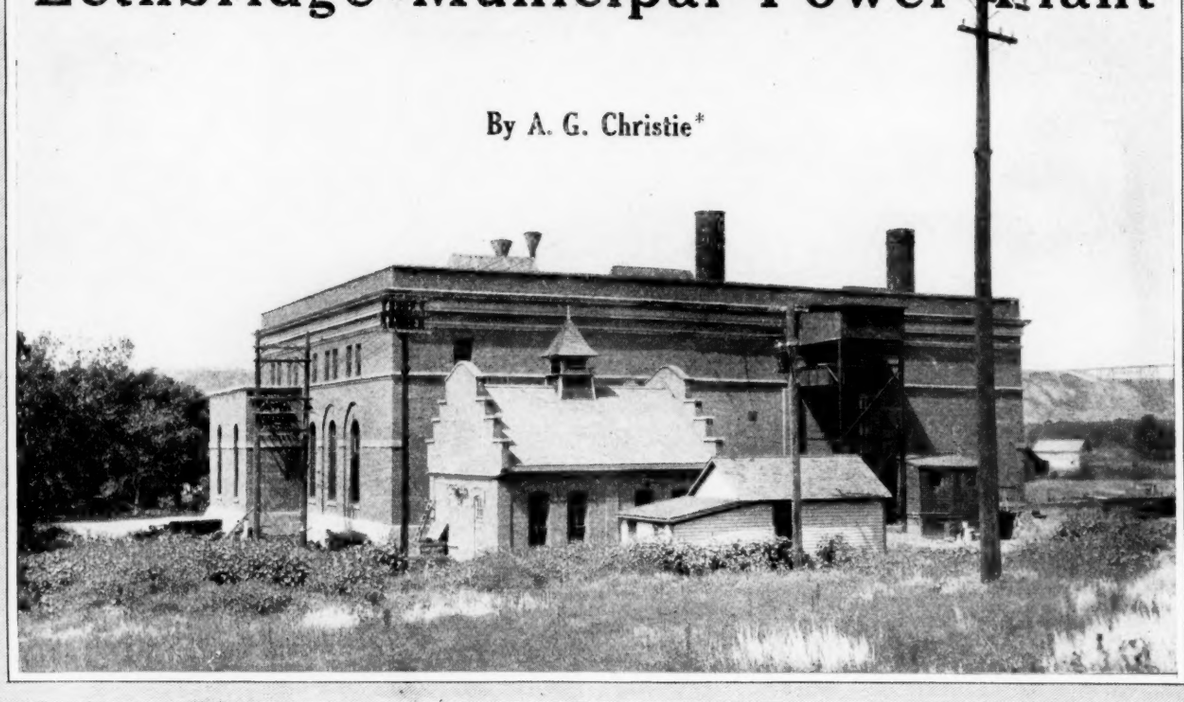


SPIKING THE GUN

Lethbridge Municipal Power Plant

By A. G. Christie*



SYNOPSIS—This power plant is built a few hundred feet from a municipal coal mine. The coal is high in ash and contains about 10,000 B.t.u. The plant contains water-tube boilers, economizers, engines and a turbine generator. A sliding scale for light- and power-meter rates ranges from 7 to 10c. per kw.-hr. and from 2 to 6c. per kw.-hr. respectively. The flat rate for motor service is from $13 to $21 per hp. per yr. for motors ranging from 25 to 151 hp. and above.

Lethbridge, the leading city of southwestern Alberta, with a population of about 10,000, operates its own municipal electric plant. In 1908 the city bought out a private company which had a franchise to furnish electricity in the city and which at the time was charging 14c. per kw.-hr. for service. The plant was not economical, and construction was started on a new one in 1909. The old plant was shortly after destroyed by fire, and the first engine unit of 300-kw. capacity was put in service in the new station. A unit of 500 kw. was added in the fall of the same year. In 1912 additional boilers were installed and a 1,500-kw. steam turbine and generator. Abstracts from the plant records since 1910, given in Table 1, show that the load increased practically 50 per cent. per year up to the outbreak of the war. As a result of the subsequent depression the plant is now overequipped for the service required of it. The power house is below the bluffs, close to the side of the river. It has a structural-steel frame with red brick walls. The boiler room is 82x108 ft. and the engine room, 35x82 ft. The water-works pumping station is combined with a power plant, a view of which is shown in the illustration at the top of this page. Fig. 1 shows a view of the engine room.

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The Coal and Ash-Handling Apparatus

The municipal coal mine is situated a few hundred yards from the plant. About 20 years' supply is available in the leased property. The fuel supplied to the plant runs from 12 to 20 per cent. in ash, its heat value ranges from 9,000 to 10,000 B.t.u. and it costs the city $1.20 per ton of $2,000 lb. at the plant hopper. Coal is also mined for use in all municipal buildings and was supplied for poor relief during the past year.

The coal trucks are drawn from the mine to the plant by a horse. Then they are weighed, and a record of the coal

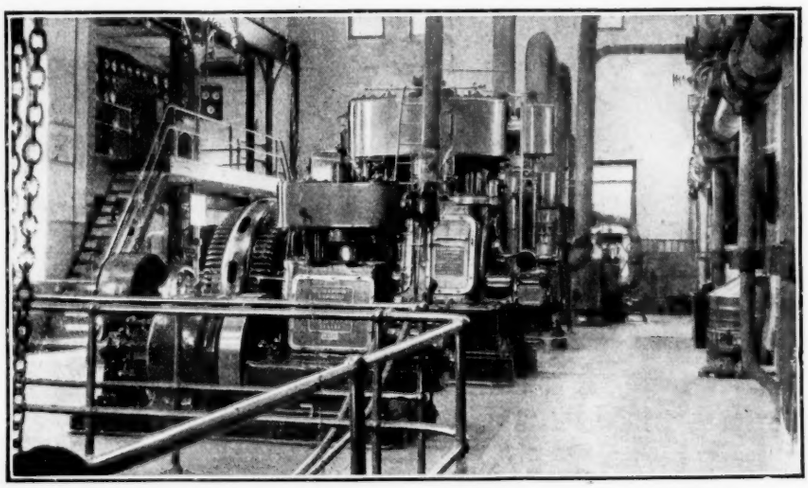

FIG. 1. VIEW OF ENGINE ROOM, SWITCHBOARD AT THE LEFT

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consumption is thus provided. The coal is dumped into a 10-ton hopper. A jig screen at the bottom sends the fine lumps to the conveyor, but the larger pieces go to a roll crusher driven by a 7½-hp. induction motor. This delivers the coal to a conveyor with pressed-steel buckets, of 20 tons per hr. maximum capacity and driven by a 3-hp. motor. The coal is elevated to bunkers of about 200 tons' capacity placed above the firing aisle and shown at the left in Fig. 3. The same conveyor removes the ashes and delivers them into a hopper-bottomed bin above the coal-unloading bin. The ashes are hauled away in steel dump cars. The boiler room contains eight-water-tube boilers with 2,823 sq.ft. of heating surface and 490 sq.ft. of superheater surface; each has two 36-in. drums 24 ft. long. A pressure of 160 lb. is carried, superheated 130 deg. Four of the boilers were installed in one row in 1909 and the others in the opposite row, in 1912. A CO_2 recorder has been installed to assist the firemen in operating the boilers efficiently.

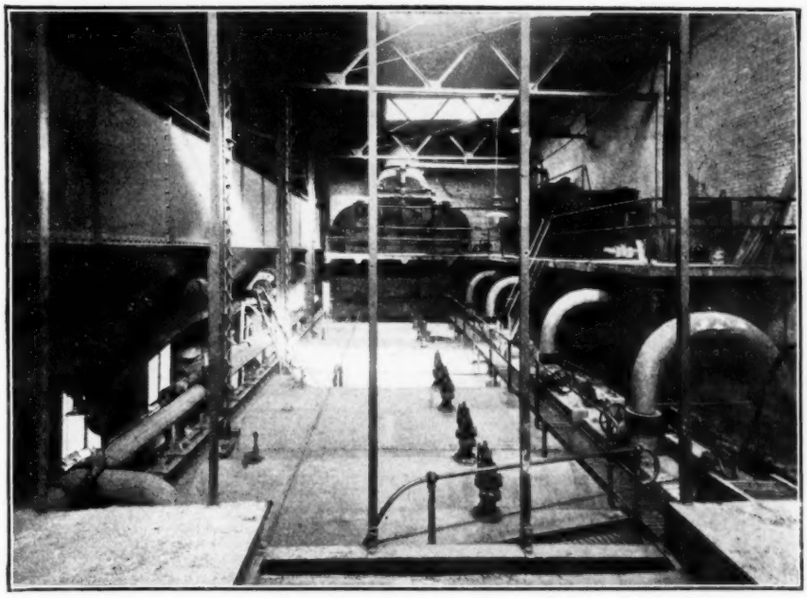


FIG. 3. VIEW ABOVE BOILERS, SHOWING COAL BUNKERS, INDUCED-DRAFT FANS AND PIPING

Each boiler furnace is equipped with a chain-grate stoker with a grate area of 55 sq.ft. per boiler. This gives a ratio of heating surface to grate surface of 51.3. Fig. 2 is a view down the firing aisle.

Each row of stokers is driven by a line shaft placed above them, which in turn receives its power through a silent-chain drive from a 10-hp. motor or by belt from a small steam engine.

The flue gases pass through flues built behind the boilers to economizers. One row of boilers is served by an economizer with a capacity of 17,460 lb. of water per hour from 90 to 200 deg. F. It contains 36 sections of 10 tubes each.

The induced-draft equipment for one row of boilers is built on a gallery above the economizer and consists of two multivane fans 57⅝ in. diameter and capable of delivering 43,700 cu.ft. of gases per minute, with 1¾-in. draft, when running at 330 r.p.m. Each fan is driven by a 5x5-in. twin engine. Either fan can handle four boilers at their normal rating. The steel smoke-stack is 5 ft. diameter and projects 14 ft. above the roof. Fig. 3 shows a view of this equipment over the tops of the boilers.

The other side of the boiler room is equipped with an economizer consisting of 32 sections of 10 tubes each. The fans are of standard plate design 72 in. diameter and 42 in. wide and will deliver 38,000 cu.ft. of gases per minute with a draft of 1½ in. of water. Each fan is driven by a 6&10x4-in. compound steam engine. The chimney for this set is of the same dimensions as that on the other side.

A water softener capable of handling 26,000 lb. of water per hour was installed. But its operation was not a commercial success, and now it is used merely to coagulate the oil in the condensed steam from the engine sets and it also filters the water. The raw water is added to this chamber. A recording meter receives the condensed steam from the turbine condenser and also, through a float-controlled valve, takes water from the softener. The recorder can be used to test the turbine, but it is generally used to measure the water fed to the boilers. All water is now treated with a compound, which is added at the recorder. The water, after measurement, flows to a 6,000-gal. two-part storage tank, built under the feed pumps for convenience in cleaning. Three 9½x7x21-in. boiler-feed pumps are in a small room at one end of the boiler room and above the storage tank. Two of these are shown in Fig. 4. Each has a capacity of 40,000 lb. of water per hour against 200 lb. pressure with 12 double strokes per minute. These three pumps deliver through a closed feed-water heater having 200 sq.ft. of heating surface. The heater is capable of raising 69,000 lb. of feed water per

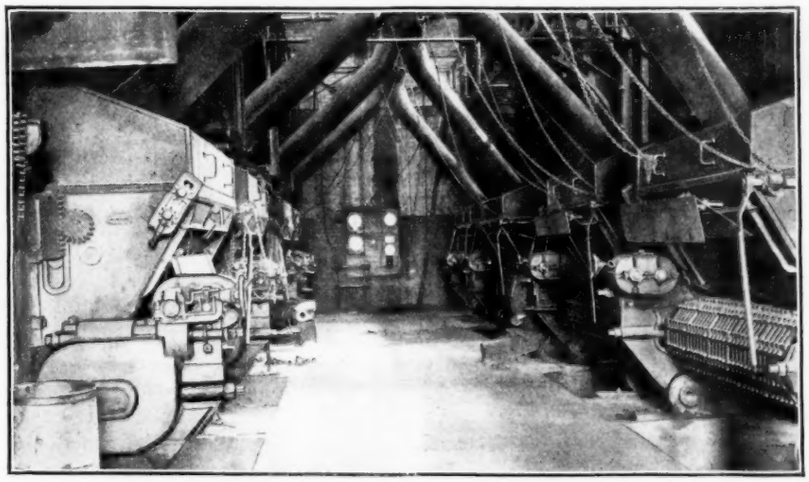


FIG. 2. THE FIRING AISLE, WITH STOKERS, COAL CHUTES AND INSTRUMENTS

hour from 33 deg. to 212 deg. F. when supplied with sufficient exhaust steam at 4 to 5 lb. pressure. The water then passes into either of two 4-in. duplicate feed lines to each row of boilers.

The header for the row of boilers farthest from the engine room is of 10-in. pipe. The 6-in. connections from the boilers consist of bends with a gate valve and an automatic nonreturn valve on each. This header is connected at either end by a 10-in. pipe with a gooseneck expansion bend to the main header in the engine room. The latter is constructed on the ring system, one pipe above the other with suitable sectioning valves. The boilers on the near side of the boiler room connect through the walls to this header. All valves and fittings are of cast steel.

The first engine installed was a 440-b.hp. 17&27x12-in. vertical-compound condensing high-speed machine running at 360 r.p.m. It is fitted with piston valves for 100 deg. superheat and has forced lubrication. The exhaust goes to a 1,100-sq.ft. surface condenser with a capacity at 2 lb. absolute pressure of 9,000 lb. of steam per hour. A two-throw 10x6-in. air pump with cylinders 10 in. is geared down to 110 r.p.m. from a 4-hp. motor running at 720 r.p.m. A 7-in. vertical centrifugal pump, driven by a 7½-hp. induction motor at 580 r.p.m., furnishes the necessary circulating water. The engine is direct-connected to a 300-kw. two-phase 2,300-volt alternator, with a 19-kw. exciter on the same shaft.

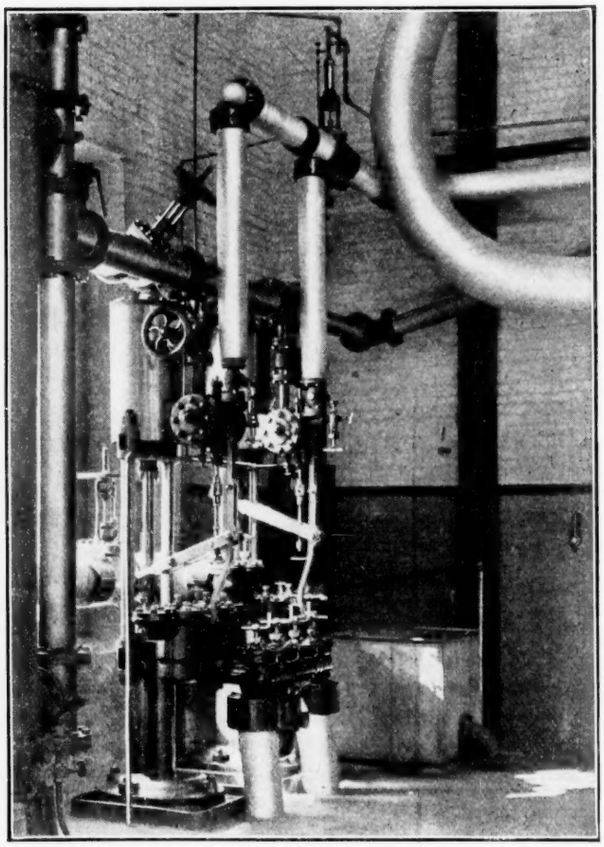


FIG. 4. TWO OF THE THREE BOILER-FEED PUMPS

The second unit is a triple-expansion vertical high-speed engine of 720 b.hp. at 360 r.p.m. It exhausts into a 1,600-sq.ft. surface condenser with a capacity of 17,000 lb. of steam per hour at 2 lb. absolute pressure. A three-throw air pump is driven at 100 r.p.m. by gears from a 7½-hp. 720-r.p.m. induction motor. An 8-in. vertical centrifugal pump driven by a 9½-hp. motor at 580 r.p.m., with a total head of about 15 ft., furnishes the circulating water. This engine drives a 500-kw. two-phase 2,300-volt alternator with a 26-kw. exciter on the end of the shaft.

TABLE 1. POWER-PLANT RECORDS, 1914

Electricity Generated:	Kw.-Hr.
Street lighting	248,960
Pumping water	370,700
Street railway	789,400
Light and power	2,000,000
Total	3,415,000
Water Pumped:	Gal.
By steam	375,774,000
By electricity	120,840,000
Total	496,614,000
Feed Water Evaporated:	Lb.
Total	137,384,733
Per lb. of coal as fired	6.55
Coal Consumed:	
For water pumping	3,006,192
For generating electricity	17,962,098
Total	20,968,290
Coal per kw.-hr.	5.25
Coal Cost:	
For water pumping	$2,405.00
For electricity	10,157.55
Total	$12,562.55
Load:	Kw.
Maximum	1,100
Minimum	40
Load Factor:	Per Cent.
Total kw.-hr. x 100 / Max. load x 24 x 365	35.4

TABLE 2. DISTRIBUTION OF OPERATING EXPENSES, 1914

Account	Total	Cents per Kw.-Hr.
Power-house wages	$14,953.84	0.4379
Fuel	12,562.55	0.3678
Water	720.00	0.0211
Oil and waste	669.74	0.0196
Power-house expense	1,783.02	0.0522
Employees' insurance	514.64	0.0152
Repairs to engines and boilers	4,746.03	0.1389
Repairs to electric plant	2,571.65	0.0753
Repairs to buildings	399.55	0.0091
Total power-house cost	$38,831.03	1.1371
Repairs to poles and wires	2,832.74	0.0829
Repairs, house services	1,289.33	0.0378
Repairs to meters	127.18	0.0037
Repairs to tools	48.24	0.0014
Street lighting maintenance	3,017.28	0.0884
Total line cost	$7,314.77	0.2142
Salaries	5,529.44	0.1619
Metermen's wages	1,080.00	0.0316
Inspections	277.05	0.0081
Office expense	2,767.85	0.0810
Total management	$9,654.34	0.2826
Total production cost	$55,800.14	1.6339
Fixed Charges:		
Debenture interest	30,071.15	0.8806
Sinking funds	16,069.72	0.4705
Taxes	8,114.67	0.2376
Fire insurance	575.92	0.0168
Total fixed charges	$54,831.46	1.6055
Total cost, including fixed charges	$110,631.60	3.2394
Total revenue	110,898.53	3.2473
Surplus	266.93	0.0079

The third main unit is a 1,500-kw. turbo-alternator of the disk-and-drum type, running at 3,600 r.p.m. It is two-phase and wound for 2,300 volts. The turbine exhausts into a surface condenser with 2,530 sq.ft. of cooling surface capable of condensing 24,300 lb. of steam per hour at 1 lb. absolute pressure. A vacuum augmenter and a three-throw 13x8-in. air pump running at 128 r.p.m. maintains the vacuum. The pump is driven through gears from a 10½-hp. induction motor running at 860-r.p.m. Cooling water is supplied by a vertical centrifugal pump with about 15-ft. head, driven at 860 r.p.m. by a 28-hp. motor.

Two other exciter sets are provided besides those on the main engine shafts. A 50-kw. 125-volt direct-current generator is driven at 600 r.p.m. by a 75-hp. compound high-speed engine that can be run either condensing or noncondensing. A motor-generator set of 30 kw., 125 volts, 1,150 r.p.m. is also provided. A plan of the plant is shown in Fig. 5.

Oil systems are used to handle all oil. A 15-ton hand crane is also installed.

The original electrical plant was built with two-phase alternators, and the city has unfortunately retained that method of distribution.

The switchboard consists of eleven panels of black slate. It is about 8 ft. above the floor in an annex on the south side of the engine room, as shown in the plan, Fig. 5. A 25-kw. arc-lamp regulator, a 16-kw. incandescent-lamp regulator and a 75-lamp mercury-arc rectifier set are installed in the same annex as the switchboard.

A substation at the car barns contains a 400-kw. and a 200-kw. motor-generator set, which convert the two-phase current into direct current for use on the street railway. The necessary switchboards, rheostats and transformers are provided in this substation.

The auditor's report for 1914 gave the cost of the property of the electric light and power department, up to Dec. 31, 1914, as follows:

Land, buildings and machinery	$451,790.17
Steel lines, poles, wires, etc.	92,887.98
House service	9,992.12
Meters	36,877.27
Total	$591,547.54

In addition to this the department owns tools to the value of $4,580.61.

Table 1 gives abstracts from the power-house records for 1914. In considering these figures it must be remembered that the coal has a heat value of less than 10,000 B.t.u. per lb.

Table 2 is taken from the auditor's statement for 1914 and shows the distribution of power costs. It has been the aim of the electric department to reduce rates from year to year instead of accumulating a large surplus. Thus customers get the benefit of reduced costs.

Several items in this statement deserve attention. First there is a fund for employees' insurance, which is unusual in the West. Fire insurance is also carried on the plant. The property of this and other public utilities is assessed and taxed at the regular city rates. The electric-light department paid taxes to the amount of $8,114.67 in 1914. If this charge were canceled the city could either show a large surplus or make lower rates to customers. It is held, however, that the omission of taxes amounts virtually to a bonus to the utility at the expense of the whole city and reduced rates under such circumstances make electric-light consumers the recipients of special privileges. On the other hand, it is always difficult to deal equitably with a large surplus and questions arise regarding the proper way to use it. Taxation places the utility in the same position as a private company and makes its rates and financing comparable with such plants.

No depreciation fund is carried, as it is estimated that the average life of the plant is just equal to the term of the bonds. The sinking funds are in charge of a committee, who may, under certain restrictions, invest them in other municipal securities.

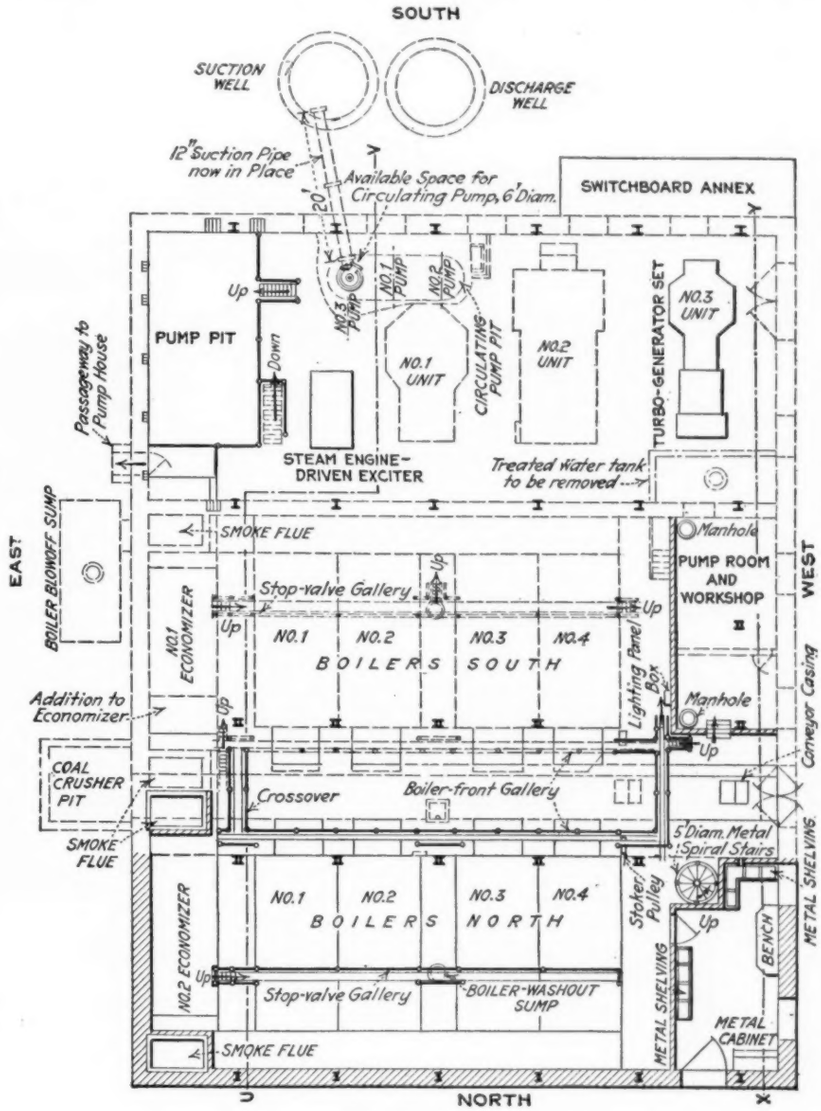


FIG. 5. PLAN OF THE TURBINE AND ENGINE ROOMS

Table 3 shows a summarized statement of costs per kilowatt-hour since the plant was built in 1910 by the City of Lethbridge.

TABLE 3. COSTS PER KW.-HR., CENTS

	1910	1911	1912	1913	1914
Power-house cost	2.42	1.89	1.43	1.20	1.14
Line cost	0.24	0.23	0.35	0.24	0.21
Management cost	0.69	0.64	0.43	0.29	0.28
Fixed charges	1.39	1.63	1.23	1.34	1.61
Total cost	4.74	4.39	3.44	3.07	3.24
Revenue	7.87	5.98	4.81	3.13	3.25
Output in kw.-hr.	1,095,000	1,471,900	2,250,300	3,450,270	3,415,000

The light and power rates put in force on Mar. 1, 1915, are shown in Table 4.

To obtain the rates under the off-peak schedule the consumer must install a time switch, which will be under the control of the city and be adjusted by the city to conform with the following hours:

Between the hours of 1 a.m. and 6 p.m. from Feb. 1 to Dec. 1.

Between the hours of 1 a.m. and 4:30 p.m. from Dec. 1 to Feb. 1.

Street railway power, 2c. net.

TABLE 4. LIGHT AND POWER METER RATES

Light Rates

	Cents per Kw.-Hr.
Up to 100 kw.-hr. per month	10
101 to 300 kw.-hr. per month	9
301 to 600 kw.-hr. per month	8
Above 601 kw.-hr. per month	7

10 per cent. discount in 10 days.

Power Meter Rates, Peak Schedule

If the consumption is less than 50 kw.-hr. per month lighting rates are charged:

	Cents per Kw.-Hr.
50 to 250 kw.-hr. per month	6
251 to 500 kw.-hr. per month	5.5
501 to 1,000 kw.-hr. per month	5
1,001 to 3,000 kw.-hr. per month	4
Above 3,001 kw.-hr. per month	3.5

10 per cent. discount in 10 days.

Power Meter Rates, Off-Peak Schedule

If the consumption is less than 100 kw.-hr. per month lighting rates are charged:

	Cents per Kw.-Hr.
100 to 500 kw.-hr. per month	5
501 to 1,000 kw.-hr. per month	4
1,001 to 3,000 kw.-hr. per month	3
Above 3,001 kw.-hr. per month	2

10 per cent. discount in 10 days.

TABLE 5. POWER FLAT RATES

These rates do not apply to motors rated less than 25 hp.

Motors From	Hp. per Yr.
25 to 50 hp	$21
51 to 75 hp	19
76 to 100 hp	17
101 to 150 hp	15
Above 151 hp	13

The rates in Table 5 are charged on the maximum rating of the motor connected. In the event of a customer taking more than the rated motor power the city reserves the right to make a test and adjust the rate accordingly.

To obtain the foregoing flat rates, the consumer must confine the use of power to the following hours:

From 6 a.m. to 6 p.m. from Feb. 1 to Dec. 1.

From 7 a.m. to 4:30 p.m. from Dec. 1 to Feb. 1.

For the use of power outside these hours the rate will be doubled.

Flat rates are net and payable monthly in advance.

The power sold to the city for lighting is metered at the plant and is charged to the city at the estimated total cost of production, including fixed charges. This lighting must be paid for out of the city's general tax fund.

It will be noticed that there is no service charge and no minimum charge per month in force. This may account for the rates being higher than in other places where such charges are made. It must also be remembered that the electric-lighting utility has to compete with natural gas that sells for 35c. per 1,000 cu.ft. for domestic use and for 15c. per 1,000 cu.ft. for commercial purposes. The low load factor indicates that the city has a modest off-peak power load. The plant is operating considerably under its capacity, so that costs and rates ought to decrease as the load builds up.

A weekly statement is made out, covering the power generated, the coal burned, the water pumped and the costs, and this is posted in the power plant where the operating men can see it. This acts as an incentive to hold down costs.

The commissioner of public utilities, Arthur Reid, directs the electric-power plant, the water-works pumping station, the coal mine and the street-railway system. Credit is due to him for the foregoing information.

Sawmill Waste in Suction Producer Plant

By George S. Wilson*

SYNOPSIS—Results of test with hogged mill waste, fir bark and Douglas fir cubes. The ordinary hogged mill waste gave the best results when the moisture was about 30 per cent. of the oven-dry weight.

During the latter part of 1915 an investigation was carried on by the mechanical engineering department of the University of Washington, in coöperation with the Seattle Laboratory of the United States Forest Service, for the purpose of determining: (1) The efficiency of Douglas-fir mill waste when used as a fuel in a producer plant; (2) the effect of the size of the fuel on the plant efficiency; (3) the effect of the moisture content of the fuel on the plant efficiency.

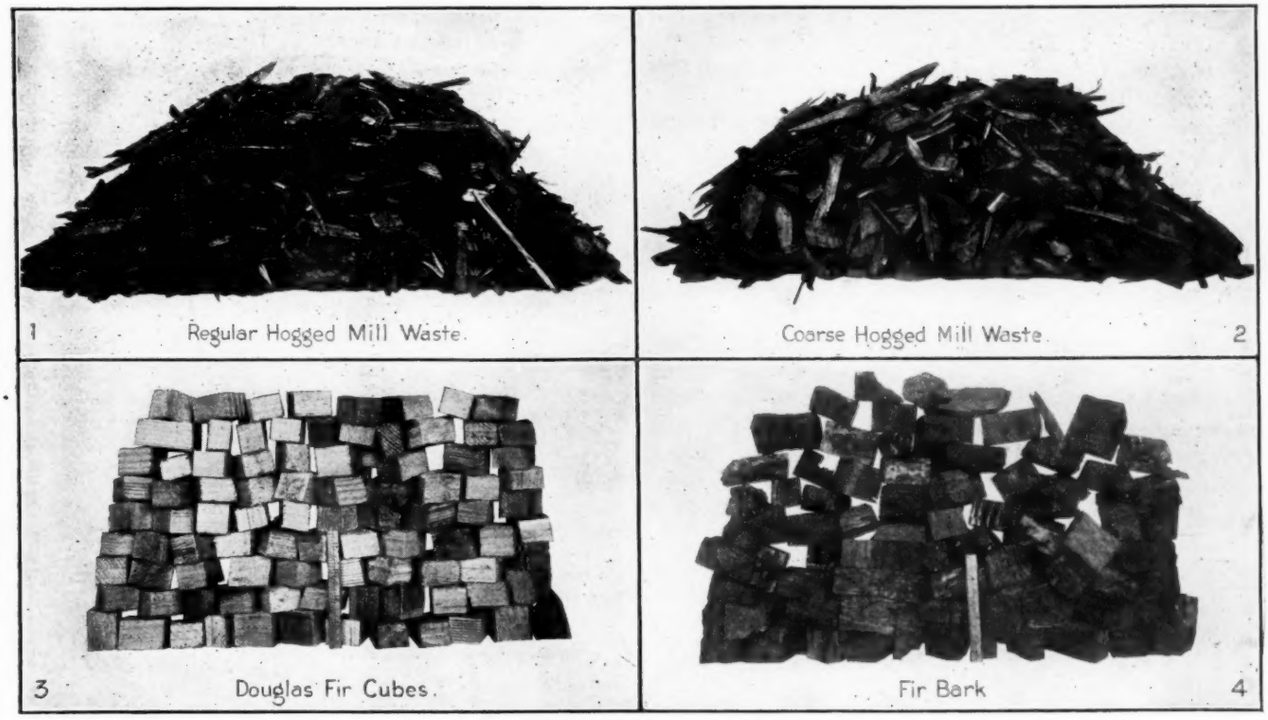
The producer had an inside diameter of 22 in. and was of the ordinary up-draft type built by the Otto Gas Engine Co.; see Fig. 5. The tar extractor was motor-driven at 1,750 r.p.m. Gas was supplied to an 11.5x19.25-in. single-cylinder single-acting engine built by the same company and rated at 27 b.hp. It has a hit-and-miss governor and a make-and-break ignition.

*Associate professor, department of mechanical engineering, University of Washington.

Each morning the blower was operated for 15 to 30 min. until good gas appeared. The engine was started, the fuel bed was brought up to the required level, and the load was put on the engine. The test was then started and continued for eight hours, during which time the fuel was fired at regular intervals, the fire being poked occasionally to prevent holes forming in the fuel bed. Just before the close of the test the fuel bed was brought to the starting level.

A constant load was kept on the engine by a prony brake, and indicator diagrams were taken at regular intervals. Revolutions and explosions per minute were counted at stated intervals and checked by continuous counters. Temperatures and pressures of the gas were taken at the producer and near the engine. Water for the tar extractor was measured by a small meter, and when the vaporizer was in use, its supply of water was weighed. The power used by the tar extractor was determined by a wattmeter.

Samples of each grade of wood were taken and the moisture content and heat value determined. By using a small pressure blower, gas was drawn from the line and delivered, under a small pressure, to a Junker's calorimeter. The value given is the high heat value at 62 deg. F. and atmospheric pressure.



FIGS. 1 TO 4. SAMPLES OF FUELS USED DURING THE TESTS

An analysis of the gas was made at frequent intervals, and an average of several determinations made while the hogged waste was being used for fuel showed for the wet fuel: Carbon dioxide, 7.02 per cent.; illuminants, 0.32; oxygen, 2.55; carbon monoxide, 20.96; hydrogen, 5.45; methane, 0.50; and nitrogen, 63.20. For the air-dried fuel it showed: Carbon dioxide, 4.35 per cent.; illuminants, 0.47; oxygen, 3.40; carbon monoxide, 21.38; hydrogen, 4.54; methane, 0.12; and nitrogen, 65.74. Considerable difficulty was found in getting consistent hydrogen and methane determinations, and the following selected analysis is probably a better indication of the make-up of the gas: Carbon dioxide, 8.39 per cent.; illuminants, 0.61; oxygen, 1.46; carbon monoxide, 21.98; hydrogen, 5.58; methane, 2.28; and nitrogen, 59.70 per cent.

The mixture of water and tar leaving the tar extractor was piped to a settling basin, when the tar separated from the water quite readily. This separation gave a heavy black tar, and the average quantity was about 11 gal. per cord of fuel. The tar content varies somewhat with the kind and condition of the fuel, and the hogged mill waste apparently yields a little below the general average.

Samples Nos. 1, 2, 3 and 4 were hogged mill waste from the hogging machine, in which condition it contains considerable sawdust. Fig. 1 shows a representative pile of this fuel.

Sample No. 1 was tested just as the fuel was received, while No. 2 was dried until the moisture content was about 30 per cent. of the oven-dry weight. The tests with sample No. 3 were made with the fuel in the same condition as in sample No. 1, but the load carried by the engine was greater. Sample No. 4 was tested under the same conditions as No. 3, but the vaporizer was in use. The vaporizer furnished 0.27 lb. of water per brake horsepower-hour.

This fuel gives a gas of fairly uniform quality, and no trouble was experienced in keeping the plant operating under steady load. The gas outlet of the producer would gradually accumulate a deposit of tar and sawdust, and it was necessary to remove this deposit before starting the blower in the morning. This required about 20 min. and, with the lighter load, was done every other day. When the load was increased, it was found necessary to clean the gas outlet each morning.

Samples Nos. 5, 6 and 7 were coarse hogged mill waste and were prepared by screening out the sawdust contained in the regular hogged waste. Fig. 2 shows a representative pile of this fuel. The tests with sample No. 5 were made with the fuel as received, while No. 6 was dried

SUMMARY OF TESTS, WITH SAWMILL WASTE IN SUCTION PRODUCER PLANT

Sample number	1	2	3	4	5	6	7	8	9	10	11
Number of tests	5	3	2	2	5	3	2	3	1	2	2
B.t.u. per cu.ft. gas	128	129	130	115	128	142	143	150	148	164	152
B.t.u. per lb. dry fuel	8,760	8,760	8,760	8,760	8,740	8,740	8,740	8,740	8,740	8,740	10,300
Indicated horsepower	26.9	....	31.4	32.0	28.7	27.8	27.5	27.3	28.2	27.3	27.6
Gross brake horsepower	17.6	18.3	21.1	21.1	18.3	18.3	18.3	18.3	18.3	18.3	18.3
Horsepower used by extractor	2.56	3.19	3.40	3.30	2.84	2.87	3.32	3.30	3.15	2.29	3.04
Moisture:											
Percentage of oven-dry weight	81.5	29.4	84.1	78.9	95.0	20.9	20.9	40.4	9.9	9.9	66.7
Percentage of fuel as received	44.9	22.7	45.7	44.1	48.7	17.3	17.3	28.8	9.0	9.0	40.0
Fuel consumption:											
As fired—											
Lb. per i.hp.-hr	3.44	....	3.14	3.05	3.47	2.57	2.47	3.08	2.82	2.52	2.52
Lb. per gross b.hp.-hr	5.24	3.35	4.68	4.62	5.45	3.90	3.71	4.59	4.35	3.76	3.78
Lb. per net hp.-hr	6.14	4.05	5.58	5.49	6.45	4.63	4.53	5.60	5.26	4.30	4.54
Dry fuel—											
Lb. per i.hp.-hr	1.90	....	1.71	1.70	1.79	2.13	2.04	2.10	2.57	2.30	1.51
Lb. per gross b.hp.-hr	2.89	2.59	2.55	2.58	2.80	3.22	3.06	3.27	3.96	3.43	2.27
Lb. per net hp.-hr	3.38	3.13	3.04	3.06	3.33	3.83	3.74	3.98	4.78	3.91	2.72

until the moisture content was about 21 per cent. of the oven-dry weight. No. 7 was the same as No. 6, but the vaporizer was in use. The vaporizer here furnished 0.46 lb. of water per brake horsepower-hour. No trouble was experienced in keeping the plant operating, and the gas outlet on the producer required cleaning only at comparatively long intervals.

Samples Nos. 8, 9 and 10 were Douglas-fir cubes; see Fig. 3. No. 8 was prepared by sawing green fir lumber into cubes, and No. 9 was prepared by sawing mill ends into cubes. These mill ends had a moisture content of about 10 per cent. of their oven-dry weight. Sample No. 10 was the same as No. 9, but the vaporizer was in use, supplying 0.26 lb. of water per brake horsepower-hour. This fuel handled conveniently and apparently produced no clogging at the gas outlet of the producer.

Sample No. 11 was Douglas-fir bark sawed and broken into rough cubes, as shown in Fig. 4. This fuel is convenient to handle, and no trouble of any kind was experienced in operating with it. A summary of the tests is given in the table, and Fig. 6 shows the fuel consumption under the various conditions. In examining the results it should be kept in mind that the plant in which these tests were made is a coal-producer plant. The producer did not have sufficient grate surface to allow a full load to be carried on the engine with all the fuel samples, and the load carried was about two-thirds of the engine rating. The efficiency was therefore lower than should be expected in a well-proportioned plant. Since all the tests were made with about the same load, a direct comparison can be made of the results obtained with the various samples. Fig. 7 shows the thermal efficiency of the plant with the various samples and shows that samples Nos. 1, 2, 3, 4, 5 and 11 gave plant efficiencies in excess of 10 per cent. even with the low load factor.

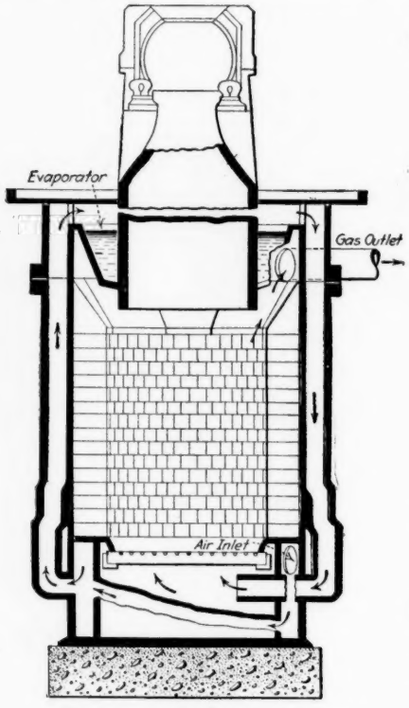


FIG. 5. SECTION THROUGH PRODUCER

Fig. 8 shows the fuel consumption plotted against the moisture content in percentage of oven-dry weight. Curve 1 is plotted with the results obtained with samples 1, 2, 5 and 6, and indicates the effect of the moisture content on fuel consumption with this class of fuel. Curve 2 is plotted with the results obtained with samples 8 and 9 and would seem to indicate that in this type of producer blocks of wood are not apt to be as efficient as the hogged material. Curve 3 is plotted from the results obtained with samples 7 and 10 and would seem to indicate that when the moisture content of the fuel is below about 20 per cent., the efficiency of the plant may be increased by the use of a vaporizer. Curve 4 is plotted from the results obtained with samples 3 and 4 and indicates a lower fuel consumption with the increased load factor. It would also seem to indicate that the use of a vaporizer does not

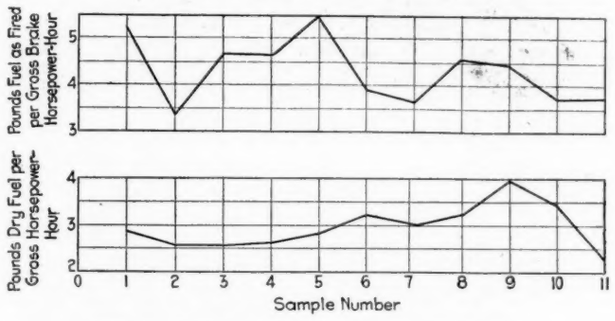


FIG. 6. FUEL PER HORSEPOWER-HOUR

increase the plant efficiency when the moisture content is large. The conclusions to be drawn from the test are:

1. Douglas-fir sawmill waste can be used efficiently in a well-proportioned gas producer. To promote easy and reliable operation, careful attention should be given to the tar extractor, so that no tar is carried to the engine. The producer should be constructed so that the gas outlet will not fill up, or means should be provided for cleaning the outlet while the producer is in operation.

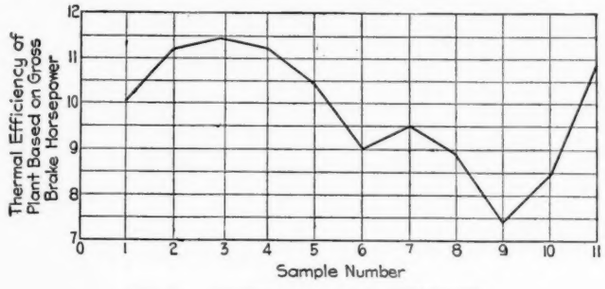


FIG. 7. THERMAL EFFICIENCIES

2. In this type of producer the hogged fuel gave the best efficiency, and the regular hogged waste is the desirable fuel, since it can be readily obtained. One of the larger mills gives the price of hogged mill waste as 0.5c. per cu.ft. A cord of hogged mill waste will weigh from 2,600 to 2,800 lb., so that where this fuel is available at

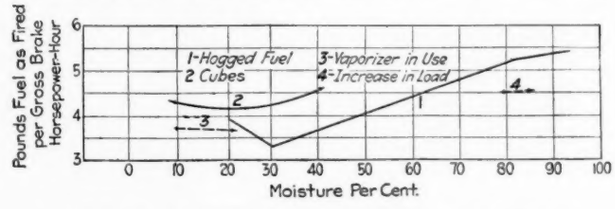

Pounds Fuel as Fired per Gross Brake Horsepower-Hour
1-Hogged Fuel 2 Cubes
3-Vaporizer in Use
4-Increase in Load
Moisture Per Cent.

FIG. 8. FUEL CONSUMPTION VERSUS MOISTURE

such a price the fuel cost in a plant would be small—from 0.1c. to 0.15c. per net hp.-hr.

3. The ordinary hogged mill waste apparently gives the best results when the moisture content is about 30 per cent. of the oven-dry weight, but good efficiencies may be obtained when the moisture content is considerably larger. The use of the vaporizer is of no advantage unless the moisture is below 20 per cent. of the oven-dry weight.

Efficiency Tests of Commercial Steam-Pipe Coverings*

By L. B. McMillan†

SYNOPSIS—The effect of varying the temperature difference from the pipe surface to the air, between 0 and 500 deg. with different commercial coverings up to 3 in. thick. It was established that the loss for any covered pipe is a function of the temperature difference between the surface of the covering and the air.

When one considers that each square foot of bare pipe in continuous service at 150 lb. pressure loses in a year an amount of heat that costs more than two dollars to generate, while the cost per year of effective covering is only a small fraction of that amount, it is apparent that there is great need for accurate data on the efficiencies of the various commercial insulating materials now in use.

Most of the tests, the results of which are now in use, were made 15 or 20 years ago, and the investigators did not attempt to make their results apply to conditions other than those prevailing at that time. Therefore large errors would be made in applying their conclusions to present-day conditions.

The work herein described has been carried on for about two years at the University of Wisconsin, and every effort has been made to secure accurate and consistent results. The effect on heat losses of varying the temperature difference between the pipe surface and the air from 0 to 500 deg. F. has been thoroughly investigated, and the conclusions reached will be fully explained. Different thicknesses of material up to 3 in. were tested and the laws confirmed by which the results may be extended to any thickness whatsoever.

Two other factors of importance, the effects of which have not yet been determined, are the character of the surface and the velocity of air currents passing over it; these are now being investigated. However, both were kept practically constant during the tests described, so that influences from these causes were avoided.

The method followed in the tests was to heat a section of covered pipe by means of an electric heater immersed in oil inside of the pipe. The heat loss was calculated by measuring the energy required to maintain the surface of the pipe at a constant known temperature. Under such conditions it is evident that just enough energy is being supplied to compensate for the losses through the covering; otherwise the excess or deficiency of energy will cause the pipe to heat up or cool off as the case may be. An illustration of the apparatus used for the tests is shown in Fig. 1, and Fig. 2 shows diagrammatically the general arrangement of the apparatus.

The electrical rather than the condensation method of testing was adopted because the electrical method is capable of much closer temperature control, the range over which the temperature may be varied is much greater, and the results obtained are of higher accuracy than is possible with the condensation method under ordinary conditions.

Referring to Fig. 2, the 15-ft. length of pipe in the center between the covered ends was the test section. The covering on the ends remained in place throughout the entire series of tests, and a correction was made for the losses through these portions by testing a short section made up as nearly like the ends of the long pipe as possible. This short section is shown in Fig. 2 at the center on the extreme left. The difference between the loss from the short pipe under the same conditions represents the loss from the 15-ft. section covered with five standard lengths of commercial covering.

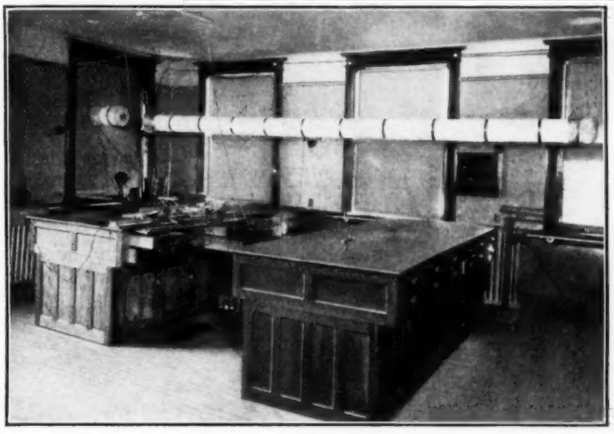


FIG. 1. APPARATUS USED IN PIPE-COVERING TESTS

The oil in the pipes was circulated to insure uniform temperatures at different points on the surfaces. The power required to drive the circulating propeller was measured for each pipe, and it was found to be extremely small in comparison with the energy supplied to the heater coils. Furthermore, it was found that the power required for either pipe was the same within the limits of error of measurement; therefore the error which would be introduced by neglecting the heating effect of stirring the oil disappears entirely in the net result, which is the difference between the losses from the long and from the short pipe.

The method of measuring temperatures on the pipe surface deserves special notice. Copper-constantan thermocouples were embedded in the metal of the pipe, and the e.m.f.'s of these were measured by an accurately calibrated slide-wire potentiometer. This arrangement was sensitive to changes of 0.2 deg. F.

In order to apply the results involving a known temperature of pipe surface to steam conditions, where the steam temperature is known but that of the pipe is not, it is necessary to establish a relation between the two. Some difference of temperature between the steam and pipes must exist in order that heat will flow from the steam to the pipe. This difference of temperature has

*A more detailed account of the tests may be found in a paper presented by the author at the last annual meeting of the American Society of Mechanical Engineers.

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been entirely neglected by most former investigators, being accurately measured by none and considered not to exist by some. In the present case, however, it was reasoned that since there must be such a difference in temperature, it would be highly desirable to know just how great it actually is under various conditions. Therefore, with steam in the pipe the temperatures of the steam and of the outside surface of the pipe were measured very accurately by means of the thermocouples and potentiometer, and the results of these measurements are given in Figs. 3 and 4.

Fig. 5 shows the drop in temperature through the wall of a steam pipe, based on the data plotted in Figs. 3 and 4. It shows that with covered pipe there is very little drop in temperature from saturated steam to the outside surface of the pipe. However, with superheated steam there seems to be at the inner surface of the pipe a sort of insulating film which allows the pipe to remain at a temperature considerably lower than that of the steam.

Therefore radiation will be lower from pipes carrying superheated steam than from those carrying saturated steam at the same temperature as that of the pipe carrying superheated steam is nearly 2 per cent. less than from one carrying saturated steam under the conditions of the test.

The curve showing total losses from bare pipe, Fig. 6, is of particular interest because former investigators have generally considered it as being a straight line beginning at the origin. The rate curve showing the B.t.u. per degree temperature difference per square foot per hour, on the same assumption, was taken as a line parallel to the horizontal axis; that is, the heat flow was assumed to be directly proportional to the temperature difference between the pipe and the room.

An analysis of the case will show, however, that such could not be true and that the rate curve must have some such shape as is shown in Fig. 6. Such analysis shows that the heat flow is made up of two components, radiation and convection, and it must increase more rapidly than as the first power of the tem-

The drop in temperature from superheated steam to the outside of the pipe is about 2 per cent. of the total drop from steam to air, therefore the radiation from a superheated steam, because the lower the pipe temperature the lower will be the radiation, other things being the same.

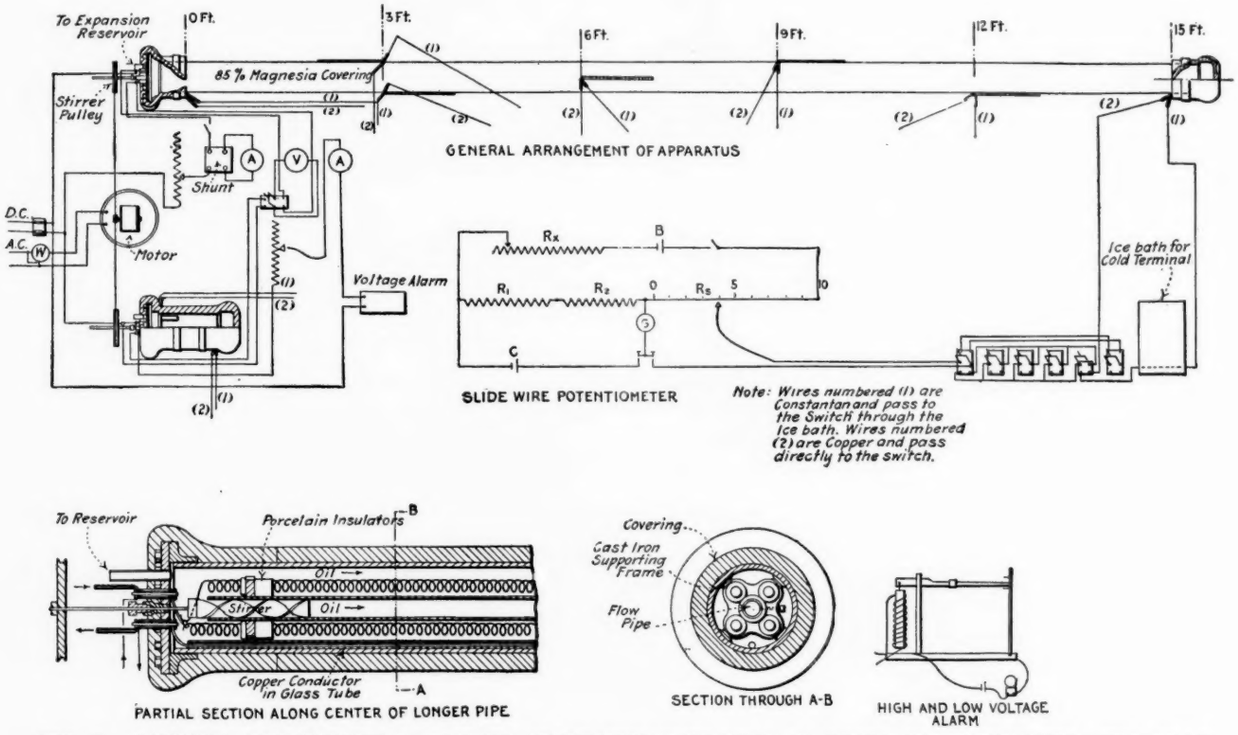


FIG. 2. SHOWING ARRANGEMENT OF THE APPARATUS EMPLOYED IN TESTS FOR OBTAINING THE HEAT LOSSES THROUGH PIPE COVERINGS

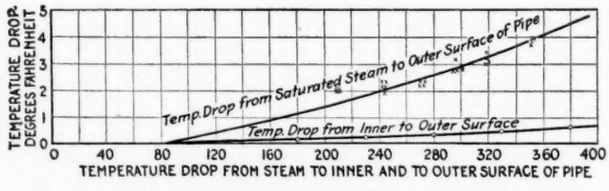

TEMPERATURE DROP DEGREES FAHRENHEIT
Temp. Drop from Saturated Steam to Outer Surface of Pipe
Temp. Drop from Inner to Outer Surface
TEMPERATURE DROP FROM STEAM TO INNER AND TO OUTER SURFACE OF PIPE

FIG. 3. TEMPERATURE DROP WITH COVERED PIPE FOR SATURATED STEAM ONLY

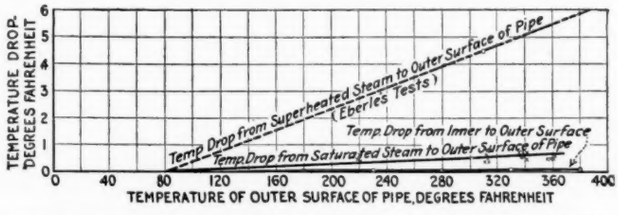

TEMPERATURE DROP DEGREES FAHRENHEIT
Temp. Drop from Superheated Steam to Outer Surface of Pipe (Eberles Tests)
Temp. Drop from Inner to Outer Surface
Temp. Drop from Saturated Steam to Outer Surface of Pipe
TEMPERATURE OF OUTER SURFACE OF PIPE, DEGREES FAHRENHEIT

FIG. 4. TEMPERATURE DROP WITH UNCOVERED PIPE FOR BOTH SATURATED AND SUPERHEATED STEAM

perature; because according to Stefan's law the radiation increases as the fourth power of the absolute temperature.

The results from all the tests of single-thickness coverings have been assembled in one chart, Fig. 7. It is noticeable from this chart that the coverings with large air spaces have made steeper rate curves than those with

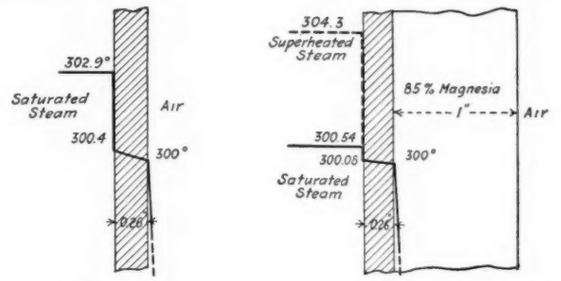


FIG. 5. TEMPERATURE DROP FROM STEAM TO OUTSIDE OF PIPE

very small air spaces. This is because of radiation and convection within the spaces, which cause a more rapid increase of flow at the higher temperatures for the same reasons as already referred to for bare pipe.

All the coverings tested were bought on the open market, and the dealers were given no intimation that the coverings ordered were to be tested. In every case shipment was so prompt as to remove any suspicion that the order was filled from other than stock material.

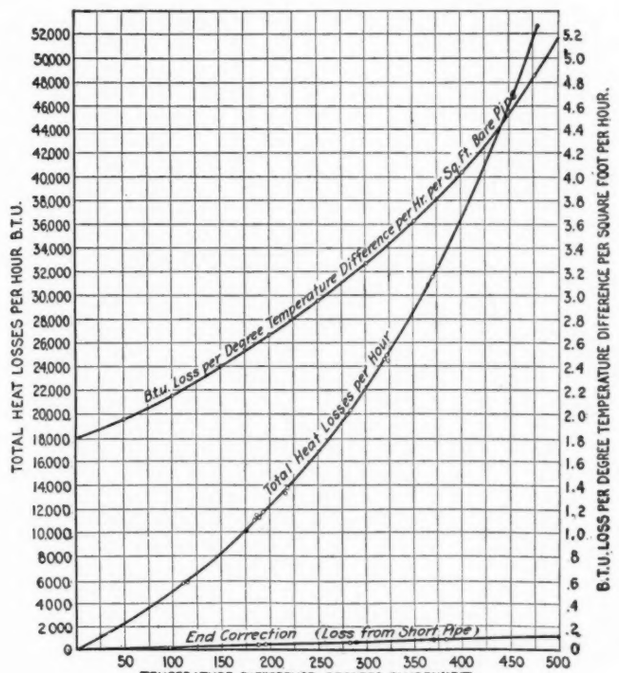

TOTAL HEAT LOSSES PER HOUR B.T.U.
B.T.U. LOSS PER DEGREE TEMPERATURE DIFFERENCE PER SQUARE FOOT PER HOUR.
Btu. Loss per Degree Temperature Difference per Hr. per Sq. Ft. Bare Pipe
Total Heat Losses per Hour
End Correction (Loss from Short Pipe)
TEMPERATURE DIFFERENCE - DEGREES FAHRENHEIT
(PIPE TEMP. - ROOM TEMP.)

FIG. 6. TOTAL LOSSES FROM BARE PIPE

From the curves shown one can tell at a glance what coverings are the most efficient at any temperature. Of all the coverings tested, the four best, at temperature differences of 200 to 500 deg., are J-M Asbestos-Sponge Felted, Nonpareil High-Pressure, Carey 85 Per Cent. Magnesia and J-M 85 Per Cent. Magnesia, ranking in the order named, with the first well ahead of all the others. However, the manufacturer of the covering fourth

TABLE I. DATA ON EFFICIENCIES AND SAVINGS FOR SINGLE-THICKNESS COVERINGS

Kind of Covering	Temp. Dif. (Pipe Room), Actual Temp. (Room = 80° F.)	B.t.u. Loss per Sq.Ft. per Deg. Temp. Dif. per Hr. Bare Pipe	Covered Pipe	Saving Due to Covering per Deg., per Sq.Ft. per Hr.	Efficiency of Covering, Per Cent.	Saving Due to Covering in B.t.u. per Sq.Ft. per Yr.	Saving in Dollars per Sq.Ft. per Yr.	First Cost of Covering per Sq.Ft.	Cost of Covering per Sq.Ft. per Yr.	Net Saving in Dollars per Sq.Ft. per Yr.
J-M 85% Magnesia	50 130	1.950	0.435	1.515	77.7	664,000	0.199	0.238	0.033	0.166
	100 180	2.152	0.438	1.714	79.6	1,502,000	0.451	.....	.....	0.418
	200 280	2.665	0.446	2.219	83.3	3,887,000	1.165	.....	.....	1.132
	300 380	3.260	0.455	2.805	86.1	7,370,000	2.212	.....	.....	2.178
	400 480	4.035	0.469	3.566	88.4	12,490,000	3.750	.....	.....	3.717
	500 580	5.180	0.488	4.692	90.6	20,560,000	6.165	.....	.....	6.132
J-M Indented	50 130	1.950	0.472	1.478	75.6	647,300	0.194	0.214	0.030	0.164
	100 180	2.152	0.483	1.669	77.6	1,462,000	0.438	.....	.....	0.408
	200 280	2.665	0.509	2.156	80.9	3,777,000	1.133	.....	.....	1.103
	300 380	3.260	0.549	2.711	83.2	7,120,000	2.136	.....	.....	2.106
	400 480	4.035	0.603	3.432	85.1	12,020,000	3.608	.....	.....	3.578
	500 580	5.180	0.666	4.514	87.1	19,780,000	5.935	.....	.....	5.905
J-M Vitribestos	50 130	1.950	0.626	1.324	67.9	580,000	0.174	0.381	0.053	0.121
	100 180	2.152	0.654	1.498	69.6	1,312,000	0.394	.....	.....	0.341
	200 280	2.665	0.715	1.950	73.2	3,417,000	1.025	.....	.....	0.972
	300 380	3.260	0.781	2.481	76.0	6,519,000	1.955	.....	.....	1.902
	400 480	4.035	0.856	3.177	78.8	11,130,000	3.340	.....	.....	3.287
	500 580	5.180	0.967	4.213	81.4	18,450,000	5.540	.....	.....	5.487
J-M Eureka	50 130	1.950	0.440	1.510	77.4	661,000	0.198	0.262	0.037	0.161
	100 180	2.152	0.451	1.701	79.0	1,490,000	0.447	.....	.....	0.410
	200 280	2.665	0.464	2.201	82.6	3,860,000	1.158	.....	.....	1.121
	300 380	3.260	0.478	2.782	85.4	7,310,000	2.192	.....	.....	2.155
	350 430	3.627	0.487	3.140	86.6	9,620,000	2.888	.....	.....	2.851
J-M Molded	50 180	1.950	0.517	1.433	73.4	627,600	0.188	0.190	0.027	0.161
	100 180	2.152	0.522	1.630	75.8	1,428,000	0.428	.....	.....	0.401
	200 280	2.665	0.539	2.126	79.8	3,725,000	1.117	.....	.....	1.090
	300 380	3.260	0.561	2.699	82.8	7,088,000	2.126	.....	.....	2.099
	400 480	4.035	0.596	3.439	85.2	12,050,000	3.615	.....	.....	3.588
J-M Wool-Felt	50 130	1.952	0.386	1.564	80.2	684,700	0.205	0.214	0.030	0.175
	100 180	2.152	0.400	1.752	81.4	1,535,000	0.460	.....	.....	0.430
	200 280	2.665	0.421	2.244	84.2	3,930,000	1.179	.....	.....	1.149
	300 380	3.260	0.442	2.818	86.4	7,400,000	2.220	.....	.....	2.190
	350 430	3.627	0.453	3.174	87.6	9,730,000	2.919	.....	.....	2.889
Sall-Mo Expanded	50 130	1.950	0.409	1.541	79.0	674,600	0.202	0.248	0.035	0.167
	100 180	2.152	0.427	1.725	80.2	1,511,000	0.453	.....	.....	0.418
	200 280	2.665	0.464	2.201	82.6	3,856,000	1.156	.....	.....	1.121
	300 380	3.260	0.503	2.757	84.6	7,240,000	2.172	.....	.....	2.137
	400 480	4.035	0.541	3.494	86.6	12,240,000	3.672	.....	.....	3.637
	500 580	5.180	0.581	4.599	88.8	20,140,000	6.042	.....	.....	0.007
Carey Carocel	50 130	1.950	0.358	1.592	81.6	697,000	0.209	0.195	0.027	0.182
	100 180	2.152	0.378	1.774	82.4	1,555,000	0.467	.....	.....	0.440
	200 280	2.665	0.421	2.244	84.2	3,932,000	1.180	.....	.....	1.153
	300 380	3.260	0.466	2.794	85.7	7,340,000	2.202	.....	.....	2.175
	400 480	4.035	0.510	3.525	87.4	12,350,000	3.705	.....	.....	3.678
	500 580	5.180	0.562	4.618	89.2	20,220,000	6.066	.....	.....	6.039
Carey Serrated	50 130	1.950	0.454	1.496	76.7	655,000	0.197	0.214	0.030	0.167
	100 180	2.152	0.468	1.684	78.2	1,475,000	0.443	.....	.....	0.413
	200 280	2.665	0.506	2.159	81.0	3,782,000	1.135	.....	.....	1.105
	300 380	3.260	0.546	2.714	83.3	7,132,000	2.140	.....	.....	2.110
	400 480	4.035	0.587	3.448	85.4	12,075,000	3.622	.....	.....	3.592
	500 580	5.180	0.634	4.546	87.8	19,900,000	5.970	.....	.....	5.940
Carey Duplex	50 130	1.950	0.423	1.527	78.3	669,000	0.201	0.162	0.023	0.178
	100 180	2.152	0.447	1.705	79.2	1,494,000	0.448	.....	.....	0.425
	200 280	2.665	0.498	2.167	81.3	3,798,000	1.139	.....	.....	0.116
	300 380	3.260	0.548	2.712	83.2	7,128,000	2.140	.....	.....	0.117
	350 430	3.627	0.574	3.053	84.2	9,360,000	2.808	.....	.....	2.785
Carey 85% Magnesia	50 130	1.950	0.413	1.537	78.8	673,000	0.202	0.200	0.028	0.174
	100 180	2.152	0.418	1.734	80.5	1,519,000	0.456	.....	.....	0.428
	200 280	2.665	0.424	2.241	84.1	3,929,000	1.179	.....	.....	1.151
	300 380	3.260	0.436	2.824	86.6	7,420,000	2.226	.....	.....	2.198
	400 480	4.035	0.454	3.581	88.8	12,550,000	3.765	.....	.....	3.737
	500 580	5.180	0.472	4.708	90.9	20,610,000	6.183	.....	.....	6.155
Sall-Mo Wool-Felt	50 130	1.950	0.395	1.555	79.8	681,000	0.204	0.190	0.027	0.177
	100 180	2.152	0.401	1.751	81.4	1,535,000	0.461	.....	.....	0.434
	150 230	2.400	0.421	1.979	82.5	2,600,000	0.780	.....	.....	0.753
	200 280	2.665	0.433	2.232	83.8	3,910,000	1.173	.....	.....	1.146
	250 330	2.951	0.455	2.506	84.9	5,484,000	1.645	.....	.....	1.618
	300 380	3.260	0.459	2.801	85.9	7,360,000	2.208	.....	.....	2.181
Nonpareil High Press.	50 130	1.950	0.399	1.551	79.5	679,000	0.204	0.224	0.031	0.173
	100 180	2.152	0.402	1.750	81.3	1,533,000	0.460	.....	.....	0.429
	200 280	2.665	0.412	2.253	84.6	3,950,000	1.185	.....	.....	1.154
	300 380	3.260	0.426	2.834	86.9	7,448,000	2.234	.....	.....	2.203
	400 480	4.035	0.444	3.591	89.0	12,580,000	3.774	.....	.....	3.745
	500 580	5.180	0.465	4.715	91.0	20,640,000	6.190	.....	.....	6.159
J-M Fire Felt	50 130	1.950	0.694	1.256	64.4	550,000	0.165	.....	.....	0.118
	100 180	2.152	0.711	1.441	67.0	1,262,000	0.379	0.333	0.047	0.332
	200 280	2.665	0.749	1.916	71.9	3,360,000	1.008	.....	.....	0.961
	300 380	3.260	0.795	2.465	75.6	6,480,000	1.944	.....	.....	1.897
	400 480	4.035	0.845	3.190	79.0	11,175,000	3.353	.....	.....	3.306
	500 580	5.180	0.901	4.279	82.6	18,740,000	5.620	.....	.....	5.573
J-M Sponge Felted	50 130	1.950	0.336	1.614	82.7	707,000	0.202	0.333	0.047	0.165
	100 180	2.152	0.347	1.805	83.8	1,581,000	0.474	.....	.....	0.427
	200 280	2.665	0.369	2.296	86.2	4,035,000	1.211	.....	.....	1.164
	300 380	3.260	0.391	2.869	88.0	7,540,000	2.262	.....	.....	2.215
	400 480	4.035	0.414	3.621	89.8	12,690,000	3.809	.....	.....	3.762
	500 580	5.180	0.439	4.741	91.5	20,770,000	6.230	.....	.....	6.183
J-M Asbestocel	50 130	1.950	0.418	1.532	78.5	671,000	0.201	0.262	0.037	0.164
	100 180	2.152	0.429	1.723	80.0	1,510,000	0.453	.....	.....	0.416
	200 280	2.665	0.454	2.211	83.0	3,876,000	1.163	.....	.....	1.126
	300 380	3.260	0.493	2.767	84.8	7,272,000	2.181	.....	.....	2.144
	400 480	4.035	0.544	3.491	86.5	12,230,000	3.670	.....	.....	3.633
	500 580	5.180	0.609	4.571	88.2	20,020,000	6.006	.....	.....	5.969
J M Air Cell	50 130	1.950	0.459	1.491	76.4	655,000	0.196	0.190	0.027	0.169
	100 180	2.152	0.475	1.677	77.9	1,469,000	0.441	.....	.....	0.414
	200 280	2.665	0.515	2.150	80.7	3,769,000	1.130	.....	.....	1.103
	300 380	3.260	0.571	2.689	82.7	7,066,000	2.120	.....	.....	2.093
	400 480	4.035	0.643	3.392	84.1	11,885,000	3.568	.....	.....	3.541
	500 580	5.180	0.733	4.447	85.8	19,475,000	5.841	.....	.....	5.814

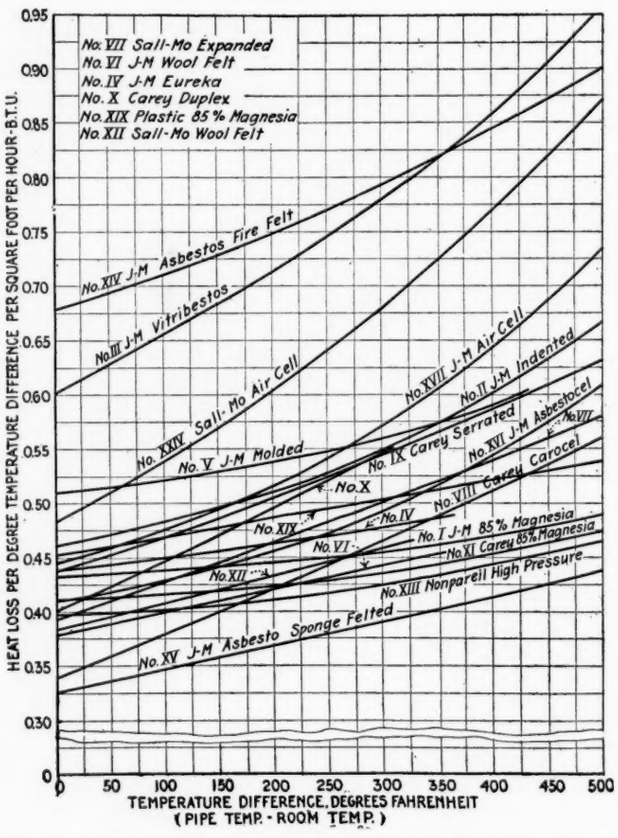

No. VII Sall-Mo Expanded
No. VI J-M Wool Felt
No. IV J-M Eureka
No. X Carey Duplex
No. XIX Plastic 85% Magnesia
No. XII Sall-Mo Wool Felt
No. XIV J-M Asbestos Fire Felt
No. III J-M Vitribestos
No. XXIV Sall-Mo Air Cell
No. V J-M Molded
No. XVII J-M Air Cell
No. II J-M Indented
No. IX Carey Serrated
No. XVI J-M Asbestocel
No. VIII Carey Carocel
No. I J-M 85% Magnesia
No. XI Carey 85% Magnesia
No. XIII Nonpareil High Pressure
No. XV J-M Asbesto Sponge Felted
HEAT LOSS PER DEGREE TEMPERATURE DIFFERENCE PER SQUARE FOOT PER HOUR-B.T.U.
TEMPERATURE DIFFERENCE, DEGREES FAHRENHEIT
(PIPE TEMP. - ROOM TEMP.)

FIG. 7. SUMMARY OF RESULTS ON SINGLE-THICKNESS COVERINGS

from the top claims that while the test is correct for the material tested, he is now turning out a product superior to that sold two years ago when this was purchased.

The saving in dollars per year due to use of covering has been calculated for each of the coverings tested, and the results appear in Table 1. Also, the first cost of the covering is taken account of, and values of net saving and percentage of saving on investment are given for values of temperature differences of from 1 to 500 deg. F. The saving in B.t.u. per degree temperature difference per square foot per hour was first found for each temperature by subtracting from the bare pipe loss at that temperature the loss from covered pipe at the same temperature. Then the total saving per square foot for a year of 365 twenty-four hour days was found by multiplying the saving per degree per hour per square foot by 8,760 and by the temperature. The cost of heat was taken at $0.30 per million B.t.u., which is nearly equivalent to $0.30 per 1,000 lb. of steam. Using this value, the saving in dollars per square foot per year was computed. The first cost of covering was ascertained from the manufacturers, and 10 per cent. of list price was added for erecting and 10 per cent. more for painting. The cost of covering per year was taken as 14 per cent. of the total first cost, the 14 per cent. including interest, depreciation, repairs, insurance, etc. The difference between the total saving per year and the cost of covering per year is the net saving per year. In the foregoing computations the period of effective service was assumed to be the same for all coverings.

While the actual values of saving given would not apply to conditions other than those assumed, those conditions are fairly near average as to cost of covering, etc., and for different lengths of service and different prices of steam the proportionate saving may easily be estimated from the figures given.

Fig. 8 shows the effects on heat losses of various thicknesses of 85 per cent. Magnesia covering, the thicknesses ranging from 0 to 5 in. The net savings in dollars per year, based on continuous service and steam at 30c. per 1,000 lb., are also given.

Fig. 9 is similar to Fig. 8 except that the material is Sall-Mo Air-Cell covering and the thickness does not go beyond 3 in.; the savings curves are omitted.

Fig. 10 is a chart showing the proper thickness of magnesia covering to be used at any temperature, any price of steam and any number of hours of service per year. The chart does not show values for length of service, but to use it for other periods than 365 days at 24 hr. a day, multiply the price of steam by the number of hours per year the steam line considered is in service and divide by 8,760 and, using the result as the price of steam on the chart, find the proper thickness.

For example, suppose that the pressure is 150 lb. gage, that the steam costs $0.30 per 1,000 lb. generated, and that the line is in use 12 hr. a day and 8 mo. of the year. The number of hours per year that the steam is on is therefore 2,920, or one-third the time. The price of steam to be used on the chart is 0.30 (2,920 ÷ 8,760) = $0.10. The temperature of the pipe containing steam at 150 lb. gage will be about 365 deg. F., and assuming a room temperature of 80 deg., the temperature difference between pipe and room will be 285 deg. On the chart,

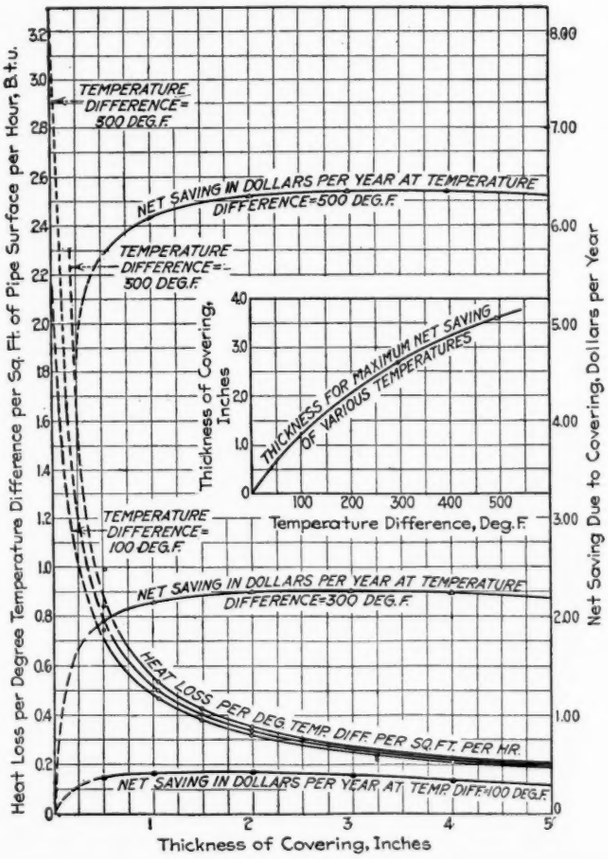

TEMPERATURE DIFFERENCE = 500 DEG.F.
NET SAVING IN DOLLARS PER YEAR AT TEMPERATURE DIFFERENCE=500 DEG.F.
TEMPERATURE DIFFERENCE = 500 DEG.F.
Thickness of Covering, Inches
THICKNESS FOR MAXIMUM NET SAVING OF VARIOUS TEMPERATURES
Temperature Difference, Deg.F.
TEMPERATURE DIFFERENCE = 100 DEG.F.
NET SAVING IN DOLLARS PER YEAR AT TEMPERATURE DIFFERENCE=300 DEG.F.
HEAT LOSS PER DEG. TEMP. DIFF. PER SQ. FT. PER HR.
NET SAVING IN DOLLARS PER YEAR AT TEMP. DIFF.=100 DEG.F.
Heat Loss per Degree Temperature Difference per Sq. Ft. of Pipe Surface per Hour, B.t.u.
Net Saving Due to Covering, Dollars per Year
Thickness of Covering, Inches

FIG. 8. THICKNESS-SAVINGS CHART FOR 85-PER CENT. MAGNESIA COVERINGS

using the curve for steam at $0.10 per 1,000 lb., the proper thickness corresponding to 285 deg. temperature difference is found to be 1.5 in. This then is the proper thickness for maximum net saving under the given conditions.

The curve, Fig. 11, showing the relation of the rate of loss per square foot of covering surface to the temperature difference between the covering surface and the surrounding air is one of the most important results obtained. Six coverings of the most diverse conductivities were tested for this relationship, and the results from all six were essentially the same, which shows that the loss from any covered pipe is a function of the temperature difference between the surface of the covering and the surrounding air. And this function is the same for all coverings having the same character of surface, regardless of what the other properties may be, since the effects of these appear in the temperature difference.

The curve just mentioned forms a new basis for approximate tests of pipe coverings. In order to find out the losses from any pipe covering having its surface finished with white canvas, all that is necessary is to place a thermometer under the canvas and another in the air 4 or 5 ft. from the pipe; take the difference between the two temperature readings and on the curve find the corresponding loss. Such a test might give results as much as 5 per cent. in error, owing to the chances of not getting the average temperature difference any closer than that, but at that it would be accurate enough for some purposes.

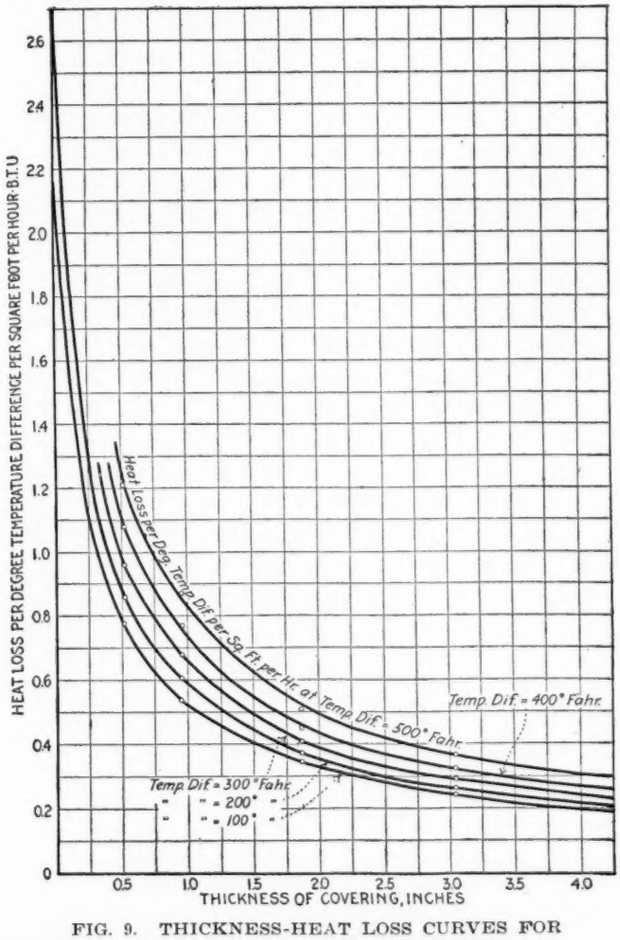

HEAT LOSS PER DEGREE TEMPERATURE DIFFERENCE PER SQUARE FOOT PER HOUR-B.T.U.
THICKNESS OF COVERING, INCHES
Heat Loss per Deg. Temp Dif. per Sq. Ft. per Hr. at Temp. Dif. = 500° Fahr.
Temp. Dif. = 400° Fahr.
Temp. Dif. = 300° Fahr.
" " = 200° "
" " = 100° "

FIG. 9. THICKNESS-HEAT LOSS CURVES FOR "SALL-MO" AIR-CELL COVERINGS

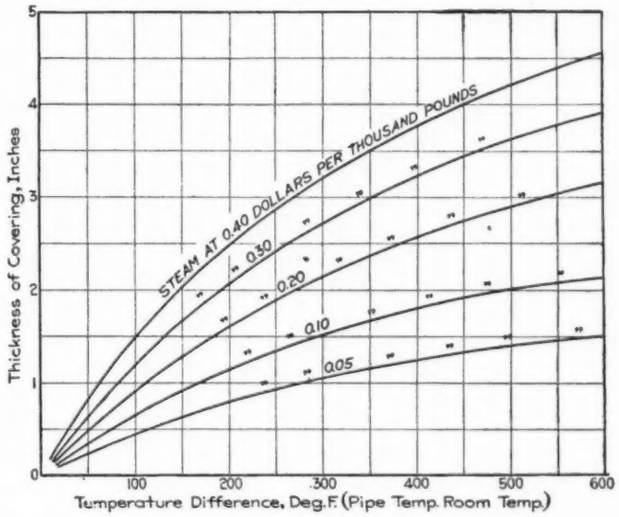

Thickness of Covering, Inches
STEAM AT 0.40 DOLLARS PER THOUSAND POUNDS
" 0.30 "
" 0.20 "
" 0.10 "
" 0.05 "
Temperature Difference, Deg. F. (Pipe Temp. Room Temp.)

FIG. 10. SHOWING PROPER THICKNESS OF 85-PER CENT. MAGNESIA COVERING FOR MAXIMUM NET SAVINGS

The same curve also furnishes the data required for solving the mathematical expression for heat loss from a covered pipe. In the equation,

$$W_2 = \frac{k\,[\theta_1 - \theta_r - f(W_2)]}{r_2\,(\log_e r_2 - \log_e r_1)} \qquad (1)$$

W_2 is the heat loss per square foot of covering surface per hour, k is the conductivity, θ_1 and θ_r are the temperatures of pipe and of air in room respectively, r_1 and r_2 are the radii of the inner and outer surfaces of the covering and $f(W_2)$ is the temperature difference between the covering surface and air corresponding to a rate of loss W_2. Values of k are given in Table 2.

TABLE 2. CONDUCTIVITIES OF PIPE COVERINGS AT 300 DEG. TEMPERATURE DIFFERENCE BETWEEN PIPE SURFACE AND ROOM

No.	Kind of Covering	Conductivity
I	J-M 85 per cent. magnesia	0.551
II	J-M indented	0.686
III	J-M vitribestos	1.087
IV	J-M eureka	0.549
V	J-M molded asbestos	0.778
VI	J-M wool felt	0.521
VII	Sall-Mo expended asbestos	0.598
VIII	Carey carocel	0.540
IX	Carey serrated	0.682
X	Carey duplex	0.636
XI	Carey 85 per cent. magnesia	0.546
XII	Sall-Mo wool felt	0.510
XIII	Nonpareil high pressure	0.543
XIV	J-M asbestos fire felt	1.093
XV	J-M asbestos sponge felted	0.468
XVI	J-M asbestos cell	0.596
XVII	J-M air cell	0.718
XVIII to XXII	Plastic 85 per cent. magnesia	0.587
XXIV	Sall-Mo air cell	0.802

The relation of loss per square foot of covering to loss per square foot of pipe W_1 may be expressed by the equation

$$W_1 = W_2 \frac{r_2}{r_1} \qquad (2)$$

Since $f(W_2)$ is not easily expressed in mathematical terms, equation (1) cannot be solved by the ordinary mathematical processes. However, it may be solved readily by trial, using the curve in Fig. 11 as the means of evaluating $f(W_2)$.

For example, let it be required to find the heat loss per square foot of pipe surface per degree temperature difference between pipe surface and air per hour if a pipe of 5.6 in. outside diameter is covered with 3 in. thickness of a material whose conductivity is 0.587 and

is maintained at a temperature of 380 deg. F. when the room temperature is 80 deg. Then from equation **(1)**

$$W_2 = \frac{0.587\,[380 - 80 - f(W_2)]}{(2.8 + 3)(log_e 5.8 - log_e 2.8)}$$
$$= \frac{0.587}{4.225}\,[300 - f(W_2)]$$

Now assume that $f(W_2) = 20$ deg. Then W_2 (using Table 2) = 25.5 B.t.u. But W_2 from equation (1) =

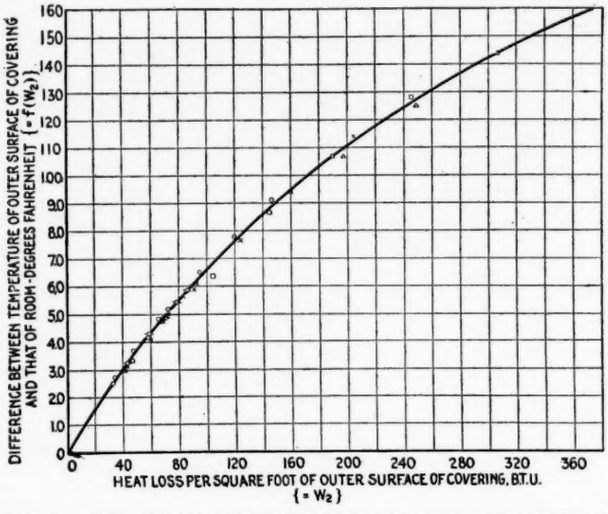


FIG. 11. RELATION OF HEAT LOSSES TO TEMPERATURE

0.139 (300 — 20) = 38.9 B.t.u. The lack of agreement between these values of W_2 shows that $f(W_2)$ should have been taken at a value greater than 20 deg. If $f(W_2)$ = 30, from Table 2, W_2 = 39.5 B.t.u. and from equation (1) W_2 = 0.139 (300 — 30) = 37.5 B.t.u. This time $f(W_2)$ was taken a little too large, and a few more trials show the correct value to be 28.8 deg. Then W_2 = 0.139 (300 — 28.8) = 37.7 B.t.u. and from equation (2) W_1 = (5.8 ÷ 2.8) × 37.7 = 78.1 B.t.u. The loss per square foot per degree temperature difference between the pipe surface and air in the room per hour, = 78.1 ÷ 300 = 0.260 B.t.u.

The trial solutions as outlined may be made quickly with the aid of a slide-rule, and the results obtained are quite as accurate as if the solutions were made by use of the ordinary processes of mathematics.

The extension of the results by mathematical means, making them applicable to any thickness of covering whatsoever, is especially desirable, since it removes the need for the almost endless number of tests that would be required to establish the same data by experimental means.

In conclusion it may be said that in most cases it pays to use the best commercial pipe covering obtainable, because where the material is paid for many times over during the first year by the saving effected by its use, the first cost loses much of its weight as a determining factor in the selection of the type of covering to be used. In view of the results of the thickness tests, it is a deplorable fact that many steam lines at the present time are not provided with thick enough covering for the greatest net saving. However, where fuel is cheap and the lines in use only a short part of the time, the cheaper coverings have their advantages. The durability also is an important factor in determining the most economical covering for a given set of conditions. Therefore a careful study of conditions is necessary before a certain type of covering can be recommended for a given piece of work.

An Engineer's Phantom Warning--I

By W. O. Rogers

SYNOPSIS—An engineer relates a strange experience with a phantom woman who suddenly appears one stormy night. She gives warning of a hidden lap-seam crack in one of his boilers and then as mysteriously disappears.

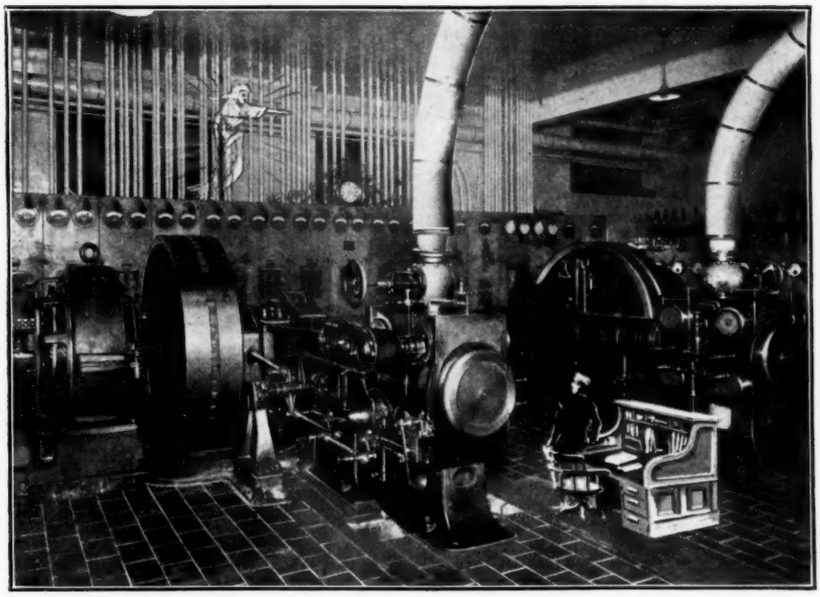
"Most people believe that if a thing is going to occur nothing can prevent it. I do not." So said Henry Westcott, night engineer at the Hardy Electric Light Plant, with whom I was on intimate terms. He was a sociable chap, and I frequently dropped into his plant during an evening to chat, and weird were some of the experiences he related.

One in particular is most vivid. We were comfortably seated in his engine room. It was a stormy night and the snow was driven past the windows in straight lines, propelled by a wind that howled and shrieked at intervals, then subsided, only to resume with renewed force. At times it seemed that the door and windows would be forced in, and their rattling, with the myriad of sounds produced by the wind, made an atmosphere such as would lead one's imagination to run riot and conjecture all kinds of ghostly fantasies.

Westcott firmly believed that each individual has a guardian spirit which watches over and guides him. I never argued the question, because I didn't know. However, you shall judge for yourself. On this particular evening Westcott told of the following hair-raising experience:

"Tonight," said he, "takes me back about ten years, when I was engineer in a manufacturing electric plant. Ever since I can remember, I have time and time again been impelled by some invisible force to do certain acts which at the time seemed needless and often foolish, but which in the end worked out to my advantage and sometimes to my safety. The influence that frequently prompted my actions was never visible until that night, one as stormy as this.

"I had just been out to the boiler room where we had three six-foot return-tubular boilers. The fireman reported everything doing nicely, a good draft and the boilers steaming freely, with steam close to the blowing-off point. As I seated myself at my desk I felt impelled to turn and look over my shoulder, and there, seemingly floating in the air among the switchboard lead wires, was the form of a woman. She was pointing toward the boilers, and her features wore an anxious, worried look.



SHE POINTED TOWARD THE BOILERS AND HER FEATURES WORE AN ANXIOUS, WORRIED LOOK

"You can be assured that I was mystified and perplexed and for a time did nothing but watch the vision. To tell the truth, I imagined I had fallen asleep and that the occurrence was a dream. Reason, however, told me that I was awake, which was proved by the steady clicking of the valve gear of the engines. I rubbed my eyes to clear them, but the phantom was still there with an even more troubled expression than at first. Impatience was also depicted, as if she were vexed because no attention was given to the efforts to attract attention, and the form moved slightly toward the boiler room, pointing as before.

"'This is strange,' said I half aloud; and getting up, I started toward the boiler-room door, whereupon the frown left the face, succeeded by a slight nod of approval. I went on and the phantom followed, but I'll swear she never went through the door. When I got into the boiler-room, I looked for my guide, and there she was, just discernible in the gloom, hovering above the middle boiler and pointing downward.

"You can well believe that my hair was beginning to lift, but I determined to follow the matter out to a finish, so I got a ladder and went up over the boilers. Everything appeared as usual, but looking in the direction in which the figure was pointing, I saw a fine vapor rising from the covering of the boiler shell. Naturally I looked for an overhead leak, but there was none. Then I began to examine the brick covering and saw that the source of the vapor was below the casing, the steam coming up through it.

"'Lap-seam crack!' I exclaimed and, looking toward my phantom, found her expression one of pleasure. Take it from me, I made a quick descent to the floor and ordered the fires under the center boiler pulled, and I made a dash for the main stop valve as soon as the steam pressure began to drop. Then with the fires out, the boiler cut out of the line and the blowoff valve opened part way, just enough to discharge as much water as came in through the feed pipe, I waited an anxious period while the steam was dropping to a point where it could do no damage. I then removed the brick covering and upon examination found that my surmise was correct—the joint was cracked, and it extended through the outside plate for a short distance. It was through this crack that the steam had escaped.

"Well, finding that crack undoubtedly prevented a bad boiler explosion and saved the life of yours truly, and all because of my phantom. When I got time I looked for her, but she was gone, out through the roof, walls or somewhere, without so much as a 'fare you well' of any kind."

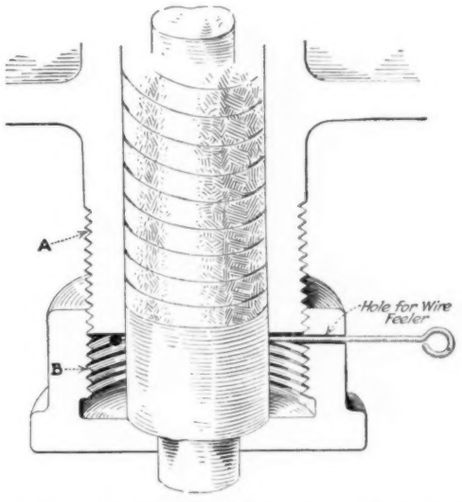
It was getting late when Westcott finished his story, and as I rose to leave I cast an apprehensive glance about the engine room, half expecting to see his phantom flitting through space. Westcott accompanied me to the door, and as I opened it, said, "Well, what do you make of it?"

I shook my head and, closing the door behind me, began plunging through the snow and fighting against the blasts of wind. What did I make of it? I couldn't answer Westcott's question because I did not know then, neither do I now.

Making a Gland Nut Safe

By Morris Ellison

An ammonia compressor was repacked, and the rods ran quite warm for a few days. The screw gland was backed off so far that it made one man nervous for fear it would come off if he loosened the gland to make the rod run cooler.



HOW THE FEELER IS USED TO PREVENT GLAND BEING BACKED OFF TOO MUCH

It was proposed to drill three holes equally spaced around the nut and down from the edge far enough so that if iron was felt through the hole the gland was on far enough to be safe, but if not it was unsafe to back off any more. The gland is shown in the sketch.

Extracts from a Refrigerating Engineer's Notebook

By H. G. Gibson

SYNOPSIS—Notes dealing with various troubles experienced and repairs made in an absorption refrigerating plant.

June 15. The weak-liquor line started to leak where it enters the top of the generator. As the generator-head gaskets have lately leaked, it was decided to open the generator, fix the broken pipe and at the same time put in new head gaskets.

The liquor in the generator was backed over into the absorber and cooler through the weak-liquor line. This reduced the generator pressure to about 25 lb., below which it would not go because of the presence of foreign gases, which were blown out.

The generator had not been opened since it was installed, and no one about the plant was familiar through experience with the details of the internal arrangement. The chief had an idea that the defective pipe was threaded through and extended down into the generator shell. When the generator head next to the weak-liquor line outlet was taken off, it was discovered that the leaky pipe was not threaded through the shell, but only a short distance into the top of it. The pipe, extending from near the bottom to the under side of the top of the shell, was screwed into the shell from the under side. Had it not been thought advisable to renew the head gaskets at this time, the leaky pipe could have been repaired without taking off the head.

Lead Gaskets Have Their Faults

It was formerly the practice to use lead gaskets for the generator heads. Of late the builders have been using sheet rubber instead, the lead not being plastic enough to take care of the expansion and contraction of the joint when the plant is started and stopped.

To remove the steam-coil outlet head of the generator, it was necessary first to take out the coils. This proved to be a big job, for the following reason: When the coils were originally put in, lead gaskets were used in the bottom of the coil stuffing-boxes. This was to prevent the rubber packing, which was put in on top of the lead, from working back alongside of the coils and into the generator. The lead served its purpose too well, for it had wedged itself into the clearance space between the coil and the bottom of the stuffing-box. A chain-block had to be hitched to the coils before they could be moved.

June 22. The matter of lead gaskets for the coils was taken up with the builders, who have discontinued the use of lead bottom gaskets and recommend steel rings instead as they serve the same purpose and will not wedge into the clearance space. The builders also recommend the use of steel balls in the safety gage-glass valves on the generator, condenser, absorber and cooler, in place of the rubber balls formerly used.

When putting the generator together, the head through which the steam coils protrude was put on first; this permitted the tubes to be moved into line from the other end of the shell. After they were in they were tested with steam pressure before the other head was put on.

July 12. A water test on the generator of 180 lb. showed leaks at the analyzer-head gasket joints. It was decided to put in new gaskets and at the same time renew the trays in the analyzer. There are 13 trays in the drum, and the clearance space between the trays and drum is calked with lead rope. It was evident upon examination that the old trays should be replaced with new ones as they were warped so badly that it was necessary to break most of them to get them out. The trays weigh about 100 lb. each, and a chain-block was put up over the analyzer to handle them.

Coil in the Brine Cooler Burst

March 6. This evening one of the coils in the brine cooler burst. Before anything wrong was noticed, the ammonia spaces in the cooler, absorber, generator and condenser were filled with brine, and the gage-glasses filled with milky-white liquor.

It was clearly impossible to save anything of value from the mixture of brine and ammonia with which the several shells were filled, so a pipe was run from the bottom of the generator to the sewer and the mixture allowed to run out. A water connection was made to the suction side of the ammonia pump through which the generator was flushed out. All the valves between the different shells were left open to facilitate the ejection of the liquid and gas.

After the machine was cleared of liquor and gas the top heads of the condenser, absorber and cooler were taken off; the cooler head was removed to enable us to take out the defective coil, and the others to make possible the inspection of the inside of the shells. The bottom ends of the brine-cooler coils were disconnected, and a water test disclosed that it was the outer coil that had burst.

There is little headroom over the cooler and it was a question whether to lay the cooler down on its side or cut a hole in the floor above to get out the defective coil. The latter method was adopted.

Trouble Getting the Shell Heads Off

Considerable difficulty was experienced in getting the several shell heads off. The packing around the pipe coils protruding through the heads had been in since the plant was installed, or about twelve years. This packing, which was rubber, had to be cut out bit by bit with cold chisels before the heads could be lifted.

On disconnecting the water coils on top of the condenser and absorber, they were found to be badly choked with scale, and it was evident that they should be cleaned before the plant was started. A barrel of coil cleaner, a black liquid heavier than water, was allowed to stand in the coils for two days and was then drawn off and the coils were flushed with water, after which they were again filled with cleaner; this was repeated as long as the cleaner had any effect on the scale. The results

from the use of this compound were not as good as expected, although this may have been due to an insufficient quantity for the work to be done.

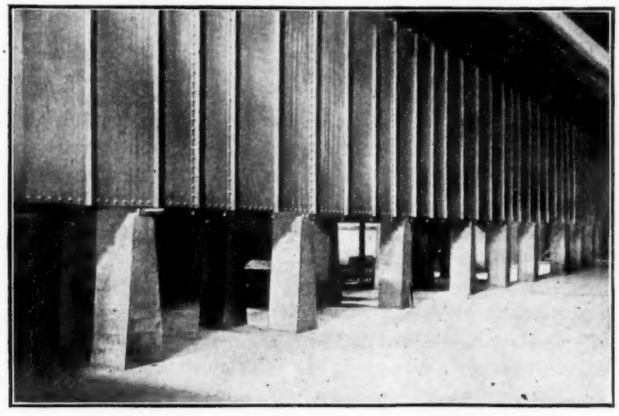
The coils of the exchanger were taken out, and after examination it was decided to replace them with new ones. These coils were connected at top and bottom by manifolds having stuffing-boxes where the coil ends entered them. These stuffing-boxes were a source of trouble because of leaks, and repacking them was a regular job. When the new coils were put in, the old manifolds were discarded and welded manifolds used. These do away with eight separate packed joints.

The generator and analyzer heads were taken off and the analyzer trays taken out; this was done to see if the brine from the bursted coil had left any deposits in these parts which should be cleaned out. No heavy deposits were found, but the generator coils and analyzer trays were thinly coated with a whitish substance. To disconnect the generator coils and take them out is hard work, as experience had demonstrated, so it was decided to leave them in and clean them by other means. The analyzer trays were cleaned with scrapers and wire brushes before being replaced. Then the generator head was put on and the analyzer, exchanger and generator shells were boiled out with a strong soda solution. The whole machine was flushed with clean water and was then ready for the ejection of the air and injection of the initial charge of ammonia.

Supporting a Metal Breeching

The different ways of supporting smoke breechings are almost as numerous as the boiler plants in which they are used. The accompanying illustration shows how the main breeching serving a plant of five 600-hp. boilers is supported on concrete piers. On the top of each pier is a saddle and roller upon which the breeching rests and is free to expand and contract.

The sheet-steel breeching is in the basement, the smoke connection from the boilers being on top. It extends



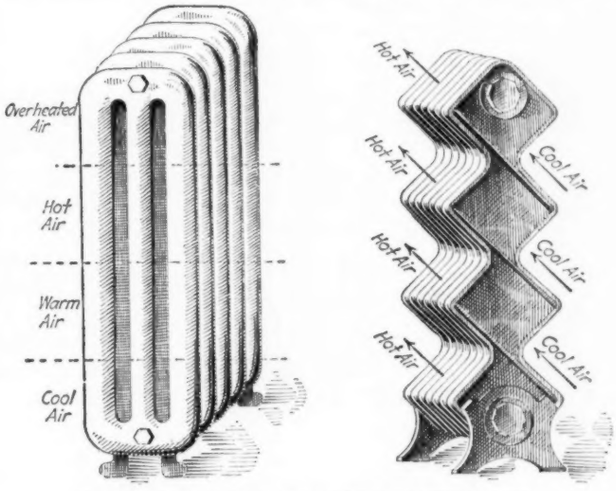
SHEET-STEEL SMOKE BREECHING

the length of the boiler-room basement and connects with a brick stack 11 ft. diameter and about 246 ft. high.

Each furnace has a grate area of 75 sq.ft., and the breeching enlarges from 3x10 ft. at the small end to 9x10 ft. at the large end, where it connects with the chimney. The greatest breeching area at the flue connection of No. 1 boiler is 40 sq.ft., at the second boiler it is 52.5 sq.ft., at No. 3 boiler 70 sq.ft., at No. 4 82.5 sq.ft., and at No. 5 it is 89 sq.ft. This gives a grate area of 1.875 sq.ft. per sq.ft. of breeching area at No. 1 boiler, 2.857 sq.ft. at No. 2 boiler, 3.2 at No. 3 boiler, 3.63 at No. 4, and 4.2 sq.ft. of grate area per sq.ft. of breeching area at No. 5 boiler and at the connection to the stack.

Air-Circulating Radiator

There has been recently brought out in France a radiator in which the circulation of air past various parts or vertical sections is the distinguishing feature; and



TWO TYPES OF RADIATORS CONTRASTED

a greater heating capacity is claimed for a given size and space occupied.

In the ordinary type the heated air passes upward along the column and becomes almost as hot as the surface of the radiator itself, so that it is unable to absorb the heat from the upper part of the radiator, at least to the extent that cooler air would. This objection is overcome by circulating the air past the radiator in independent strata, as indicated in the illustration. Oblique partitions between the sections divide the height of the radiator into any desired number of compartments to deflect the heated air away and allow other air to come in contact with the next upper section. In distributing the air and heat more thoroughly none of it becomes overheated and localized, therefore more satisfactory heating is accomplished.

The American rights for the manufacture of this radiator are under the control of Julien Champeaux, 36 Downshire Hill, Hampstead, London, N. W., England.

Errors in Measuring High-Pressure Gas occur in accepting as true for all pressures a law discovered by Sir Robert Boyle in 1662. The United States Bureau of Mines conducted experiments and finds that in measuring natural gases at high pressures there are in many instances mistakes of as great a magnitude as 10 per cent. or more where Boyle's law is used, according to which the volume of gas is presumed to vary inversely as the pressure applied to it. This is now found to be true only for pressures close to atmospheric. The report says that pressures of 300 lb. per sq.in. or greater are common. At 100 lb. the error is 3 per cent., at 200 lb. 6 per cent., at 375 lb. 11 per cent. and at 520 lb. an error of 15 per cent. has been found. Natural gas at these pressures is more compressible than an ideal gas (for which Boyle's law holds). If 50,000,000 cu.ft. of natural gas is measured per day at a pressure of 200 lb. per sq.in. and no correction is applied for the deviation from Boyle's law, then an error of about 3,000,000 cu.ft. of gas is made.

Some Brief Descriptions of Welding Processes

By M. W. Ward

SYNOPSIS—Welding by many of the various processes is being so extensively applied, and so many engineers seek a general idea of the methods that the following will prove of interest. Electric-resistance, electric-arc and oxyacetylene welding are briefly described.

Welding may be divided into two general methods—that in which temperature and pressure are used to effect the weld and that in which temperature only is used. To the first belong welding presses, power hammers, the blacksmith and the electric-resistance, or, as sometimes called, the electric-pressure weld. To the second belong the electric-arc and gas welding.

In choosing which process shall be employed for a specific case, knowledge of the methods and effects will be of considerable use.

Electric-Resistance Welding

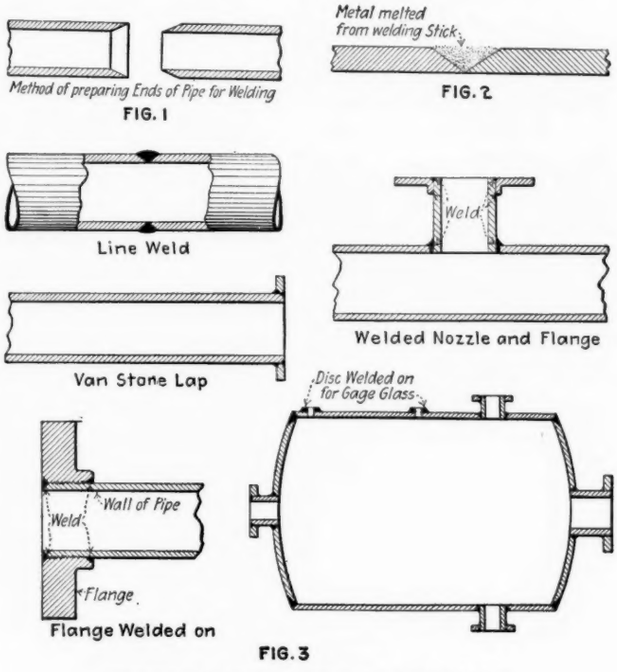
When a current of electricity is passed through the abutting ends of two pieces of metal, heat is generated, and as the place of contact is the point of greatest resistance in the circuit, if the current is allowed to continue and the two metals be forced together, the heat of the current together with the pressure will unite them. The pressure exerted to force the metals together while in a plastic state will cause a slight upsetting, or extrusion, called a burr, at the weld. Sometimes the heat will at first develop in the interior of the parts being welded, therefore the interior will be as perfectly joined as the visible exterior. The most suitable current for this process is single-phase alternating, voltage not greater than 5; the amperage will, of course, vary with the sectional area at the weld.

In Europe this method of welding is extensively used, large-diameter pipes, high-pressure steam headers, fittings and separators up to 30 in. diameter, with all flanges and seams welded, are produced. The British Board of Trade passed this class of material after exhaustive tests. Fig. 1 shows the mode of preparing the ends of pipe for welding.

European practice has demonstrated the practicability of this method up to large sizes of pipe, also tests made have shown that it can be relied on. There is little danger of burning the weld, and 95 per cent. and higher efficiency can be expected. Furthermore, less experience in handling is required than in the gas methods of welding.

In the arc method the articles to be welded are connected to the positive pole of a direct-current electrical supply, usually of 100 volts, and as originally used a carbon rod, or electrode, was connected through a resistance to the negative pole of the supply. The electrode is mounted in an insulating handle, and to commence welding the operator would bring this electrode into momentary contact with the work, striking an arc which, after producing, was maintained about three-quarters of an inch long. The electrode was then drawn along the seam to be welded, the heat of the arc (about 6,500 deg. F.) causing the metal to melt, thus forming a union. Surplus metal would be provided by introducing a stick of the same composition into the flame, allowing it to run into the work. Sometimes the heat of the arc would be used only to bring the pieces to be welded to a suitable temperature, the weld being completed by hammering or by pressure.

The use of the carbon electrode on iron or steel frequently caused the joint to be so hard that on cooling it would crack; also if the polarity was reversed, carbon



WHERE VARIOUS WELDS ARE MADE

was transported through the arc, entering into the molten metal of the joint. To overcome this trouble carbon was replaced by an electrode of metal of the same composition as that being welded.

If care is exercised, a weld by this method can be made satisfactorily. It depends upon the skill of the operator to determine the proper length of the arc for the work, also the length of time it is applied; too long an application will burn the metal, and too short will give a weld of poor strength.

This method is not efficient, as most of the heat generated is dissipated into the atmosphere; also the operator needs effective protection for eyes, hands and arms, as the arc, rich in the ultra-violet rays and those beyond the visible spectrum, affects the skin, causing it to peel off, inducing severe irritation.

The method, however, is easily portable and may be used both for original and repair work, but can be relied on only when done by expert welders given plenty of time and good facilities.

Oxyacetylene welding is done by the high temperature produced when oxygen and acetylene in certain proportions are burned by a special form of blowpipe, or torch. The oxygen is stored under pressure (usually 1,700 lb.) in a steel cylinder; the acetylene is either generated on the premises or stored under pressure the same as oxygen, except that the gas is dissolved in acetone absorbed by a suitable porous material. This is necessary to overcome the danger of explosion, which would result if the gas was compressed undissolved. The pressure in the acetylene cylinder is usually 150 lb. This way of using acetylene is to be preferred, not only on account of portability, but also on account of the purity of the gas obtainable when manufactured on a large scale in a plant specially devoted to that purpose. The steel cylinders are provided with suitable gages, pressure regulators, valves and tubing to the torch to secure proper regulation.

As originally used, this process, like the electric-arc, really belonged to the first method, the temperature only being used, as with the arc. The flame temperature of oxyacetylene is probably as high as 6,300 deg. F. More recently this process has been changed. The edges of articles to be welded are first prepared by chamfering, the torch is then applied, together with a welding stick of metal of like composition to that being welded, the edges are brought to welding temperature and a small amount of metal melted from the welding stick is allowed to flow into the joint, gradually filling the space between the chamfered edges (see Fig. 2).

Some Skill Is Required of Operator

From the explanation the idea will be gained that oxyacetylene welding is easy. It is to be regretted that this apparent simplicity has tempted too many of the unskilled to enter the field, doing considerable damage.

The making of a satisfactory weld by these methods depends on the skill of the operator, on the purity of the gases used and on the equipment. The operator, to make a good weld, must be thoroughly experienced in the handling of the torch, should have considerable knowledge of the effects of expansion and contraction of metals, should also have a knowledge of metallurgy and the service the weld is to be used for, especially when the work is in connection with boilers, steam piping or parts subjected to tension or torsional strains. It takes considerable experience to adjust the torch to give a flame that will not oxidize the work, also to determine the proper length of time the flame must be applied to secure the correct depth of fusion without burning the metal. The welded joint, if properly made, will be as ductile as the rest of the metal and can be relied upon to have an efficiency of 95 per cent. If the welded section is built up, giving a slightly greater section than the balance of the work, 100 per cent. efficiency can easily be secured. Never rush the operator or force him to put in long hours, as the work is trying to the eyes, even though protected by dark glasses, and the concentration necessary cannot long be continued without rest. A proper weld cannot be made with a shaky hand.

In Fig. 3 are shown a few of the applications of oxyacetylene welding to steam work. It will be noticed that the welded joint is shown in solid black, giving the appearance of surface welding. This is not really true, as the surfaces to be welded must be brought to a molten state, together with the metal that is added, which means that the original surface will undergo a change of shape, the added metal becoming a homogeneous part of the material to a depth depending upon the operator's skill.

The oxyacetylene method of welding is extensively employed on account of its portability. Metals such as brass, copper and aluminum are welded, requiring, however, considerable skill.

Holt Multiple Strainer

The Holt multiple basket water strainer, Figs. 1 and 2, consists of a casing in which are fitted removable baskets made of perforated metal placed between the inlet and the outlet connection so that the liquid to be strained flows into the baskets before passing out through the perforations to the outlet.

The baskets are removable, and foreign matter caught by them is easily cleaned out. The upper part of the

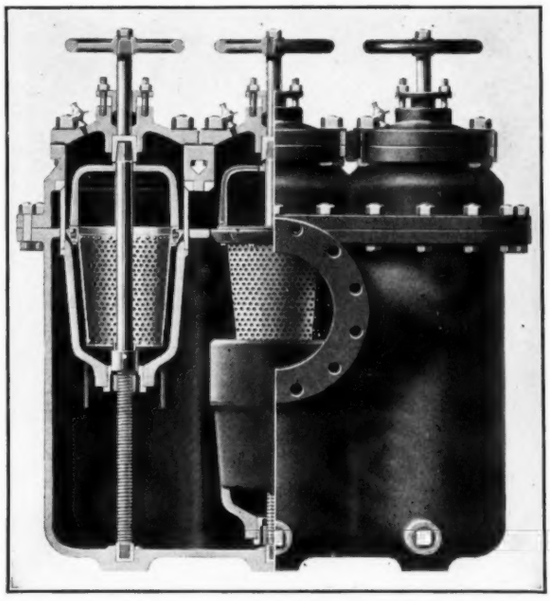


FIG. 1. SEMISECTIONAL FRONT VIEW OF HOLT STRAINER

strainer body contains a cleaning chamber and forms the connecting passage from the intake chamber to the strainer baskets.

The strainer is made with from two to eight baskets. When one basket is out of service the remaining area of the straining baskets is not less than 2½ times the area of the intake. The baskets are held in place by the collars in the valve stems. The top of each is made with a ring-shaped holder, recessed to provide a grooved way for collapsible and expanding segments, each of which is operated by a small wire spring.

The bonnet is made with a bronze beveled seat, so that by turning the valve screw with the handwheel the inclosing valve is raised and, coming in contact with the collapsible segments, pushes them back into the recessed grooves around the holder until sufficient clearance has been provided to allow the valve to continue upward and seat against the valve seat in the bonnet. The baskets are removed for cleaning separately, and each is replaced before another is removed.

A ported valve screw nut is used at the bottom of the inclosing valve and serves as a clean-out valve when the

inclosing valve is at its lowest position. When water is flowing through the perforated bottom of the basket, the direction is toward the bottom of the valve, thus washing out any mud or sand that may accumulate at this part of the valve. The velocity of the liquid through the ported valve bushing is increased as the area of the discharge is reduced. After the inclosing valve has been

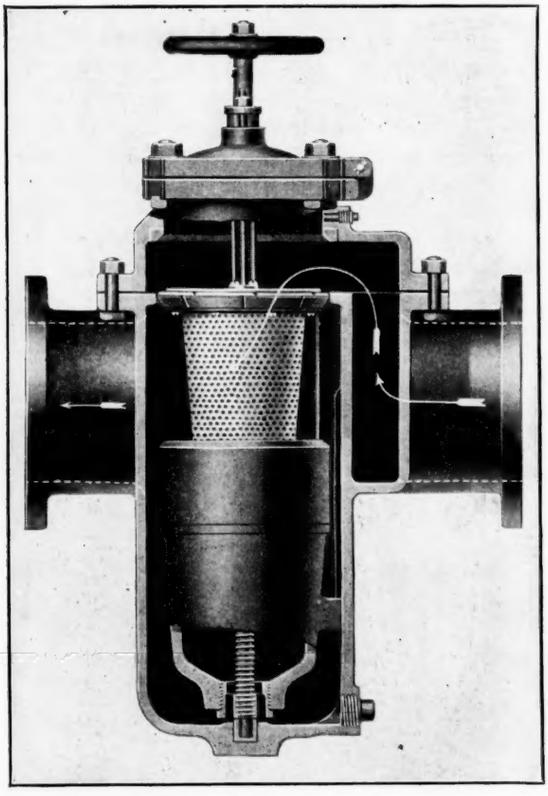


FIG. 2. SECTIONAL SIDE VIEW THROUGH STRAINER

raised to its high point, the ported bushing engages with the lower part of the valve screw collar, which is tapered to make a water-tight joint.

To clean the basket, the inclosing valve is raised by turning the handwheel that operates the valve screw to the right until the valve seats tightly, thus separating the basket in its own water-tight cleaning compartment from the main casing.

This strainer is manufactured by the Rosedale Foundry and Machine Co., Columbus and Preble Ave., Pittsburgh, Penn.

Locating Governor Trouble

By G. E. Miles

An old Ide engine that had given long and faithful service in a Western light plant finally began to be uncertain in its responding to the governor. Several times it was barely saved from running away, and the engineer in charge thought each time he had located and remedied the trouble. It finally became necessary to rebabbitt the main bearings and rebore the cylinder, and after this was done the engine again refused to be controlled by the governor.

The work on the engine was performed by an expert machinist in whom the management had great confidence. After thoroughly going over every part of the governor and valve mechanism, this machinist gave it as his opinion that the trouble was due to lack of lubrication in the valve, for when he gave the valve a liberal supply of oil, the engine ran as nicely as anyone could wish. The machinist put the load on it and kept watch over it for about half a day, and it responded to changes in load from one extreme to the other as well as any engine could.

Everything appearing to be in good shape, the machinist was about to turn the engine over to the engineers, but after shutting it down for some trifling adjustment, it again refused to be governed. This time he knew it was not lack of oil in the valve, and he could find nothing else to account for the engine's behavior. He searched and searched and tried every joint and they worked freely. He finally "phoned" to the superintendent that he was buffaloed. He said that that engine had got his "goat" and that he was compelled to admit that he could not find the trouble.

Accordingly the superintendent went to the plant. First the springs were disconnected so the governor arms could be moved with no other resistance than that of the moving parts. Every part acted freely. The movement was tried at different positions of the crankpin, but no position could be found where there was the slightest binding. Then the cap was removed from the main bearing so that the action of the eccentric could be better watched.

How Trouble Was Finally Located

Finally it was noticed that a collar on the shaft between the eccentric and the end of the main bearing was at times free to turn on the shaft and at other times was tight. Following this clue, it was found that this collar was part of a sleeve around the shaft that extended from the hub of the belt wheel to the end of the main bearing. The purpose of this collar was evidently to limit the end motion of the shaft so as to prevent the eccentric from being jammed between the hub of the wheel and the end of the bearing. So much wear had taken place where the sleeve bore against the hub of the wheel, however, that when the end motion carried the shaft in that direction the eccentric would be bound between the hub and the collar provided that this motion took place when the governor was giving the longest cutoff. The side of the eccentric was so worn where it rubbed against the collar at the position of early cutoff that no binding could occur, hence the governor behaved as long as the load was light.

After this discovery the action of the engine became easily explainable. It was only when the end motion of the shaft would catch the eccentric in the position of greatest cutoff that the binding could occur, and this had never happened when the machinist was trying to find the trouble. When he stopped the engine to look it over, all would be free and he had no clue to follow. The place where the eccentric had worn against the collar had escaped notice, and the place where the sleeve had worn against the hub of the wheel could be seen only when the engine was dismantled. If the engine got up to speed before the eccentric became pinched, it could not get pinched unless a load heavy enough to cause the greatest length of cutoff struck the engine at the same time that the end motion happened to be in that direction.

Editorials

Unfulfilled Guarantees

We have had frequent occasion to felicitate some of our manufacturing friends upon performances in excess of their guarantees, and have from time to time published tests that showed results better than those that had been promised. It is a pleasure upon our part to put such things upon record, and it is natural for the successful designer and builder to like to see his successes published and commended.

But unhappily it is not always thus. Many guarantees are made, which the apparatus fails to fulfill when it is subjected to an acceptance test, and one of our correspondents admonishes us that the practice of always publishing the successes and never the failures, of recording test after test in which conditions are more than met, but avoiding any mention of those in which the builder comes to grief, is likely to lead to a false impression with regard to the frequency with which guarantees are met, and to remissness on the part of purchasers with regard to insisting upon acceptance tests.

The correspondent is connected with a corporation that buys a large amount of apparatus and material and buys it intelligently. Guarantees of quality and performance are insisted upon, and analyses and tests are made to see that the guarantees are compiled with. Their experience is not invariably of the pleasant sort with a predisposition to publish which our correspondent chides us. A turbo-driven centrifugal pump failed to give either the guaranteed capacity or efficiency, and the more the makers worked upon it the worse it got. A turbo-generator guaranteed to run on fifty-eight pounds of steam per kilowatt-hour, at rated load, required seventy-one. Three turbine-driven pump units designed for boiler feed were returned after testing, having failed in capacity, head and steam consumption. The three pumps of another make with which these were replaced did not meet the steam-consumption guarantee within twenty-five per cent. until after the turbines had been returned to the manufacturer and renozzled. The purchaser learned that the turbines had been tested before being shipped the first time and had shown a water rate twenty per cent. above that of the guarantee, but had been sent along nevertheless, in the hope that they might not be tested or might get through somehow. A twelve-inch motor-driven pump had to be taken apart three times and have its impeller cut down before the quantity of water which it discharged was reduced to such a point that the motor would carry the excess load due to the inefficiency of the pump, which the makers admit is about twenty per cent. less than that guaranteed. Six-inch and four-inch motor-driven pumps came within five per cent. of the guarantees. There were only three faults with a couple of plunger pumps that they bought—they were poorly designed, made of poor material and with very bad workmanship. The first thing that happened after the pressure was put on them was that some of the studs pulled out of the pump chamber, and an examination showed that large blowholes had been filled with lead and the studs had been screwed into the lead plugs. The crossheads were flimsy and of poor design, and as many as six of them have been broken in a single month. The duty is below that guaranteed. The maker has furnished two new cylinders free of charge.

In view of these experiences they put a penalty of one hundred dollars per kilowatt in the contract for a motor-driven two-stage pump, and have just proved by test that it takes three kilowatts more to run it than was guaranteed, and thus will collect three hundred dollars on a purchase which amounted to less than a thousand.

Failure is not the chronic fate of the purchases of this corporation. They make many that comply amply with the representations and guarantees. It is because so many of their failures are enumerated in a couple of paragraphs that the record looks so sinister. Most of the cases cited, too, are compound units involving the efficiencies of both pump and turbine or motor, and a divided responsibility. We mention them, withholding the names, as a deterrent for ill-considered guarantees and a reminder to the purchaser that the writing of a guarantee does not establish its performance.

Aim for the Bull's-Eye

More general each year is becoming the practice of running acceptance tests to determine what might be called the ultimate efficiency of the power plant.

These tests are usually run under ideal conditions, the object being to make the plant do its best. For the test the equipment is put in the pink of condition—the most desirable coal is burned and carefully fired, the boilers are clean as a whistle, the engine is adjusted to a nicety, and everything is done to get out of the equipment all there is in it.

The acceptance test is run, a gratifyingly high efficiency is attained, the accounts of the equipment makers and the designers are paid, perhaps with a bonus for extra-high efficiency, and then what happens? Why in most plants the apparatus is just kept in repair and running, and in nine cases out of ten the high efficiency obtained in the acceptance test is never even approached—and all for the very simple reason that there is lacking the thoughtful care and attention evidenced at the time of the test. Poor and unsuitable grades of coal are used, wasteful furnace methods permitted, scale is allowed to accumulate on the boiler tubes, the nice engine adjustment is not preserved, and the auxiliary equipment is neglected—each factor accompanied by its little loss in economy.

What does it avail the plant owner to have in his archives a certificate testifying that an evaporation of nine and one-half pounds of water per pound of coal can be produced in his boilers when the operating conditions show an average of but six pounds?

The point is here: The acceptance test should not be merely something to show off the plant. Representing as it does a record and evidence of what the plant can do

and will do when it is properly operated, it should be held up as an example—the measure of the efficiency of the plant for the future.

Is your plant living up to the record made when it was accepted? If not, why not?

⁂

Catholicity in the Engineer

In the passing of Dr. C. J. H. Woodbury, secretary of the National Association of Cotton Manufacturers, engineers of every specialty lose a fellow worker with unusual sympathies and attainments. Here was a man of quiet, kindly disposition, whose interests encompassed a vast field, ranging from art and history to fire prevention and safety engineering; who counted his friends in all branches of the profession by the score, and who belonged to numerous scientific, technical and economic organizations, his knowledge of modern industry being almost encyclopedic.

An engineer by training and by experience, recognized the country over as an authority on telephone development, mill construction and textile engineering, Doctor Woodbury was appreciative none the less of the great problems of steam and electric-power production, and many a paper of interest to the operating engineer has been transmitted to the technical press through his timely courtesy. His career shows what breadth of interest an engineer in the larger sense of the word may seek and attain and illustrates a degree of catholicity that many workers in the profession cannot but strive to imitate. Mastery of details must always come first, but once that is attained, breadth of interest pays its own reward; and the cosmopolitan sympathies of such a man are a blessing indeed to all with whom he comes in contact.

⁂

Steam-Boiler Legislation

Perhaps the simplest and most expeditious way to get uniform boiler requirements in all of the states would be to procure the passage of an amendment to some appropriate law in each, specifying that on and after a given date no boiler shall be installed or used for any purpose whatsoever unless such boiler shall conform in all respects to specifications set forth in the standard Code of the American Society of Mechanical Engineers, as it is now constituted or as it may be altered hereafter. Such an amendment to the labor law is now before the New York legislature.

It is true that making the American Society of Mechanical Engineers' Code, as it is now constituted *or as it may be altered hereafter*, a part of the statutory law delegates to that society or to the committee charged with the revision of the Code some of the legislative powers of the law-making body. That this would not be sufficient, however, to render the act unconstitutional is indicated by the decision in the case of the St. Louis & Iron Mountain Ry. vs. Taylor (210 U. S., 281), in which the provision in Sec. 5 of the Safety Appliance Act, referring it to the American Railway Association and the Interstate Commerce Commission to designate and promulgate the standard height and maximum variation of drawbars for freight cars, was held to be not unconstitutional as a delegation of legislative power.

In Red "C" Oil Co. vs. North Carolina (222 U.S., 380) it was held that a requirement by the legislature that illuminating oils must be safe, pure and afford satisfactory light establishes a sufficient primary standard, and remitting to the proper state board the establishment of rules and regulations to determine what oils measure up to those standards does not amount to a delegation of legislative power.

In the case of Curtice Brothers Co. vs. Barnard (209 Fed. Rep. 589) it was held that a provision authorizing the State Board of Health to adopt rules to enforce the act with reference to the manufacture of foods and drugs, and to provide minimum standards defining specific adulterations and fixing proper methods of examining foods, drugs, etc., was not unconstitutional as conferring legislative power on the State Board of Health.

While these are all Federal cases, they cite decisions in which the same point was contended for under various laws not as nearly like the proposed bill as the laws involved in the cases cited.

⁂

In their explanations some folks seem to try to be incomprehensible.

⁂

Do not expect much from the engineering student who is afraid to get his hands dirty.

⁂

If the departed can reason, we wager that Watt could be arrested for what he thinks of the man who advocates 600 lb. steam pressure.

⁂

Grand Rapids engineer restored to life after heart stopped beating for ten minutes.—News item. Evidently he had breakdown service installed.

⁂

When you see steam blowing from a building when live steam is flowing into the heating system, be assured the engineer does not do the firing.

⁂

Indian Engineering, published in Calcutta, has an article on smoke from Cleveland. Shame on you, Cleveland! You should keep your smoke at home.

⁂

Pressure is being brought to bear to make Chicopee, Massachusetts, sell its municipal electric-light plant. One wonders who can possibly be back of the agitation.

⁂

In your judgment a boiler inspector may err altogether too far on the side of safety. That's a good sign, for it shows he appreciates his responsibility. Compromise with him.

⁂

We learn that the human element is the governing factor in welding and that even the X-ray fails to reveal how perfect a joint may be. Why not apply the ray to the operator?

⁂

Governor Samuel McCall of Massachusetts says that the function of engineering is "to put man on better terms with nature." But if you transgress her laws, you won't even be on good terms with her.

⁂

Electric power used in the lead district of Southwestern Missouri increased from 3,854,985 kilowatt-hours in November, 1914, to 7,270,890 kilowatt-hours in November, 1915—News item. One naturally expects a heavy load in this industry.

Correspondence

Heating Factory Buildings

The amount of steam used in heating systems using live or exhaust steam depends on the temperature maintained inside the building. This—the greatest variable—is seldom mentioned. Usually, when heating with exhaust, the quantity of steam available is fixed by other considerations than the outdoor temperature, so that while the building is comfortable, there is no overheating and consequent losses by opening doors or windows. It is possible, when supplying live steam through a reducing valve with a slightly higher temperature and pressure, so that a greater area of heating surface is active owing to the better circulation, to radiate considerably more heat and condense quite a lot more steam.

Another point in heating economically is that to maintain a given average temperature the heat should be supplied as uniformly as possible. It was found in some tests on heating a storehouse[1] that to maintain the same average inside temperature with steam in the pipes during the days only (from 6 a.m. to 6 p.m.) required 60 lb. pressure, while with steam in the pipes continuously 10 lb. pressure was enough, and further that heating with 60 lb. during the day consumed only about 35 per cent. more steam than with 10 lb. continuously. This excess was probably due to excessive local overheating in the vicinity of the steam coils and not shown by the thermometers giving the average temperature of the building, as well as the greater radiation at the higher temperatures it was necessary to attain to allow for cooling when the steam was off at night.

Mr. Hoffmann's letter in the issue of Jan. 11, page 53, brings up two interesting points, one of which is the effect of moving machinery on heating. This is twofold—first in that all the mechanical energy supplied by the engine is liberated as heat, so that in a factory where the power is supplied by an engine and the exhaust used for heating, practically all the heat of the live steam finally goes to heat the building—only radiation and the engine friction escaping. Besides this the moving parts—pulleys, belting, etc.—tend to stir up the air and force some of the warmer air from the ceiling down to where it will have some effect on the temperature as felt by the occupants of the room.

The second point is the effect of pulsating flow on steam-flow meters. This always makes them read high, the amount depending on the rapidity and extent of the pulsations. Tests on a flow meter to a 1,000-kw. cross-compound Corliss engine showed that it read 1.75 times the actual steam flow, and in a branch from a main header to a heating system the pulsation caused by a large engine connected to the main header caused a meter in the branch to read 30 to 50 per cent. high at low rates.

In another plant eight return-tubular boilers were connected to a large main and practically all the steam passed from one end of the header to a Corliss engine. In general the flow meters on these boilers read progressively higher toward the engine, owing to the pulsating flow caused by it. In this line and in that of the branch to the heating system it was arranged to eliminate the pulsating effect on the flow meters and make them read correctly, although the engines ran as usual.

From the results obtained in heating a large cotton mill with forced hot-water circulation, where a careful record was kept of outside and mill temperatures, steam supplied, temperature, etc., I am convinced that for any building the variable amounts of heat used under similar weather conditions will be found to depend mostly on the temperature inside the building, and unless it is carefully watched, there will be a number of doors and windows opened in an effort to correct the operation of the heating system.

H. D. Fisher.

Newton Highlands, Mass.

[1] "Cost of Heating Storehouses," H. O. Lacount, "Trans. A. S. M. E.," Vol. 29.

Boiler Tube Quickly Replaced

In *Power* of Feb. 8, 1916, under "Boiler Tube Quickly Replaced," Edward Horsfield says that a tube was renewed in 4½ hr. from the time it was discovered leaking and the boiler returned to the line.

It would be interesting to *Power* readers having charge of boiler rooms to know what means he took to reduce the temperature of the furnace, which must have been in the neighborhood of 2,300 deg. F., so that a man could work therein in a couple of hours. Will Mr. Horsfield let us have the full details of this work—that is, the means of reducing the temperature of the furnace, the time it took to fill the boiler with water, the time required to get steam up and put the boiler on the line, the time it took to get the old tube out and the new tube in; also the size of the boiler?

Alexander Arnois.

Philadelphia, Penn.

Retubing Water-Tube Boiler

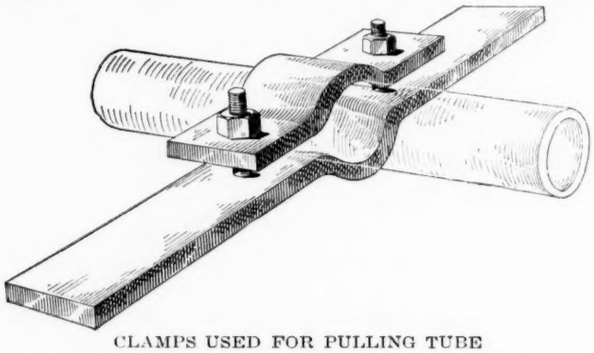
In *Power* for Oct. 26, 1915, p. 591, and Feb. 8, 1916, p. 193, are letters telling of the rapidity with which water-tube boilers were retubed at low cost. In the plants mentioned, I believe that complete sets of tubes were put in. The following gives an idea of the saving that can be made by putting in one or two tubes in a horizontally baffled boiler when the tubes to be replaced are those carrying the lower baffle.

Originally, if a tube had to be replaced, the first thing done was to remove the baffle tile. In this operation tiles on adjacent tubes were broken or stuck fast, so that they had to be replaced. Two men were used for this work. One removed tile and shoveled them out of the combustion chamber, while the other wheeled them out of the boiler room to the dump pile. It was rare that a tile could be used again.

While the operation of removing tile was going on, two other men were employed in getting the tube ready

to take out. This was done by cutting it off 18 in. from the rear end and then ripping the end of this short piece in the water-leg and driving it out. The front end was ripped in like manner and the tube driven out and removed through the firebox door. A new tube was then installed and retiled.

The time required for replacing and retiling one tube averaged from 10 to 14 hr., depending upon the damage done to baffling. Labor cost was for two laborers at



CLAMPS USED FOR PULLING TUBE

17½c. per hr. each and two mechanics at 20c. and 50c. per hr. respectively. Aside from these costs there are others, which are due to loss of the boiler from service.

The method now used saves the cost of the two laborers, the cost of new tile, and shortens the time the boiler is out of service, which in this plant is a big item. The method is a simple one. No doubt others are making use of it. The tube is ripped in the front and back water-leg and then driven out the front hole. The tile are supported by a long plank held up by jacks. On account of its being impossible to drive the tube all the way, a handy clamp was made, as illustrated. With this clamp two men can drag a tube out of a boiler in quick time. The new tube is shoved back through the tile and gives little trouble even when the old one was badly sagged causing the tile to curve out of line.

Good records of from 50 to 65 min., have been made by this manner of retubing.

Albuquerque, N. M. FRANK MCGOUGH, JR.

Two Kinds of Management

In a New England power plant I came across a prosperous-looking engineer who employs a force of neat, clean-cut men. Every man in the plant seems to take it easy, yet there is no evidence of idleness. What the men do they do well, but I thought as I watched them that surely so many men were not needed in such a small plant.

I asked the engineer apologetically, "Is this your dull season?"

"Oh, no, no," he smiled; "this is our busy season."

"Well," I ventured more timidly, "how does it happen that you have so many men working?"

The engineer smiled more broadly and asked me if I knew anything about power engineering. To my affirmative reply he recited this short story, which since has made a considerable impression on me, for it is full of things to think about:

"Before I came here this plant was run night and day by three men. All were men who did not have time to smile or think. There are six boilers here. Before I came one man was firing all those boilers. He shoveled 18 tons of coal per day, and the engineer, they say, boasted about the 'ox' in his boiler room. The plant ran in 12-hr. shifts—two shifts per day—day and night, Sundays and holidays, just as at present.

"I put in another fireman immediately and retained the 'ox.' I decided to develop him into a good man and so increased his wages 25c. per day and cut his heavy labors in half. He was indeed happy, but it was plain that he felt that he was not earning his money. He thought, you see, that he had to 'earn' his raise muscularly. That is the way in which millions of conscientious human beings regard work. They think muscle is everything.

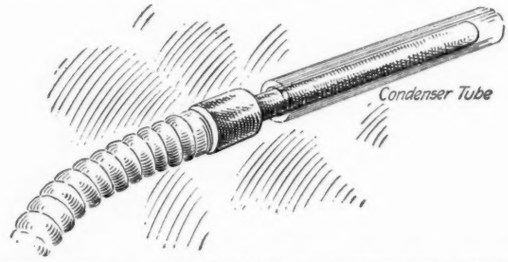
"I did the same with the night force. The original Ox No. 2 of that force was trained to look after the engines on the steadier night load in addition to his coal-shoveling duties. Yet he also managed to shovel 18 tons per night. Total, 36 tons per 24 hr., costing over $3 a ton.

"Today we burn only 26 tons of coal every 24 hr. We therefore save 10 tons per day, which amounts to $35 per day. Instead of only three men there are six now, and our combined wages do not amount to the saving. Would you suggest, now, that I fire three men and go back to the old method of perspiration and inexcusable waste of fuel?" W. F. SCHAPHORST.

New York City.

Cleaning Condenser Tubes

I have found that condenser tubes are likely to be bent or sprung so that forcing a pipe or rod through them is liable to do damage. I prefer using a close-fitting noz-



COMPRESSED AIR CLEARING CONDENSER TUBES

zle about 8 in. long, with compressed air at 75 to 100 lb. pressure to blow them out. One man cleaned 3,500 tubes in 5 hr. by this means.

The nozzle may be easily made out of pipe and a reducing fitting, as shown in the illustration.

Lyons, N. Y. WAYNE G. BROOKINS.

In the issue of Feb. 22, page 262, Mr. Wearin describes his method of cleaning surface condenser tubes, which no doubt would work very well in tubes that contained only soft scale, but I do not think that it would be successful where the scale hardens.

In this section we have a lot of trouble with hard scale, and surface condensers are very hard to clean. In one place, after a run of one week, about $\frac{1}{32}$ in. of scale was found on the tubes. Attempts to remove it resulted in failure until a new type of cutter head was obtained, after which very little trouble was experienced. In the meantime another method was used which gave good results, although very slow. This was a rod with a head peened on it pushed through the tubes.

Albuquerque, N. M. FRANK MCGOUGH, JR.

Testing the Demulsibility of Engine Oils

Our attention has been called to an article in the issue of Feb. 29, 1916, page 294, on the test for "demulsibility" of lubricating oils, developed at the Bureau of Standards, and we desire to point out certain statements which we believe might be misunderstood. Mr. Leilich says: "The question was taken up with the Bureau of Standards at Washington, and a test for deëmulsibility was suggested upon which the bureau has been working." This might be taken to mean that Mr. Leilich suggested the test to the bureau, which was not so. The development of this test was the result of original investigations, neither at the suggestion nor with the assistance of Mr. Leilich.

It is stated further that oil *A*, with a demulsibility of 0+, was "entirely satisfactory"; oil *B*, with test value of 60, was "fairly so"; and oil *C*, with value of 94, was "totally unsuited." According to the proper interpretation of the test, oil *A*, which does not settle out at all in one hour, ought to be the unsatisfactory one, and yet the article expresses the belief that the test "will furnish a reliable means of determining the suitability of a given oil."

It is a matter of minor importance, but we might add that we prefer the word "demulsibility" to "deëmulsibility," the form appearing in your article.

We inclose brief account of the test, which is the best account yet issued.

BRIEF DESCRIPTION OF THE TEST FOR DEMULSIBILITY, OR RESISTANCE OF AN OIL TO EMULSIFICATION, WITH WATER, AS DEVELOPED AND IN USE AT THE NATIONAL BUREAU OF STANDARDS

By W. H. Herschel

The test to be described is applicable to nonemulsifying oils, such as are used with high-speed engines and turbines, and in its present form does not apply to steam-cylinder or other compounded oils.

The test is made as follows: 20 c.c. of oil and 40 c.c. of water, preferably distilled, are placed in a 100-c.c. cylinder having an inside diameter of 1 in. and heated to 55 deg. C. The oil and water are then mixed or emulsified by stirring with a paddle for five minutes at a speed of 1,500 r.p.m. The paddle is simply a metal plate 3½x⅞-in. by about $\frac{1}{32}$-in. thick, conveniently driven by an electric motor.

The rate at which the oil settles out from the emulsion, when it is allowed to stand at a temperature of 55 deg. C., is a measure of the emulsibility of the oil. There is a tendency for the rate of settling out of the oil to increase up to a maximum and then decrease, and we may take readings every five minutes (or every minute if the oil separates out rapidly) and note the maximum rate. For example, the following readings were obtained for a certain oil:

Time	Time Since Stopping Paddle	Reading of Cylinder at Top of Emulsion	C.C. of Oil Settled Out	Rate of Settling, C.C. per Hr.
9.50	0	60	0	0
9.55	5	57	3	36
10.02	12	47	13	65
10.05	15	43	17	68
10.10	20	41	19	57

The maximum rate is here 68 c.c. per hr., and this is called the "demulsibility." The best transformer, motor and turbine oils settle out in one minute or less, so that if we take readings to even minutes and even c.c., the rate would be 1,200. Oils are found with rates all the way down from this maximum rate to zero.

It has been found necessary to shake the container holding the sample of oil if it has been allowed to stand for some time; otherwise the oil poured off from the top may show a different rate of settling from the oil at the bottom. It is also necessary to protect the oil from sunlight, which has the effect of decreasing the rate of settling.

With some oils under certain conditions, part of the water does not enter into the emulsion and drops of oil adhere to the sides of the cylinder. When this phenomenon occurs, the rate of settling indicated by the test is apt to be incorrectly high. The adhering drops may be avoided by using a lower speed or less water, the total quantity of oil and water being kept equal to 60 c.c. If part of the water does not enter into the emulsion, we do not have the above described phenomenon, but complete emulsification may sometimes be obtained by prolonging the stirring beyond five minutes or by increasing the speed.

It is especially important in a test of this kind that the apparatus should be reproducible, and on this account the paddle has been kept of simple shape, although a more complicated paddle might have a greater emulsifying effect. The other conditions of the test have been chosen to give a maximum effect, so as to most sharply distinguish between different oils.

The word "demulsibility" is used because a high numerical value of the rate of settling, as given by the test, indicates a high resistance to emulsification, and not a great ease of emulsifying.

Dec. 8, 1915.

It might be also of interest to point out that the test has been adopted by the General Supply Committee which makes contracts for purchasing supplies for the executive departments and other establishments in Washington.

S. W. Stratton,
Washington, D. C. Director, Bureau of Standards.

Making Exhaust Lines Safer

I agree with H. G. Schuler's suggestion in the issue of Feb. 22, page 268, in reference to making exhaust lines safer. I like to see anything as foolproof and safe as it is possible to make it.

In a large office building the separator in the exhaust line connected to the heating system became deranged by a deflecting plate on the inside getting loose and partly closing the outlet, causing excessive back pressure so the engine could hardly pull the load. If the opening had become entirely obstructed, there would in all probability have been an explosion and considerable damage to other apparatus, if only by the escaping steam. It is dangerous to put a valve in the exhaust line between the engine and back-pressure valve. Frank Drynan.

Kansas City, Mo.

Exhaust vs. Live Steam Heating

Many men are of many minds regarding relative values of live or exhaust steam for heating.

The value of steam as a heating medium is due to the fact that it is hot. If some of its heat is taken away for purposes other than heating, the remainder will not exceed the original, apparent results to the contrary notwithstanding. One factor often overlooked in the current discussion is the effect of entrained moisture in the steam. Radiator efficiency is distinctly affected by the quality of the steam supplied—not alone because of the relative value of a specific volume of wet or dry steam, but because of the moisture film that covers the interior of the radiator and retards the passage of heat.

It will be observed, by touching the tips of the fingers lightly to the surface of an ordinary cast-iron radiator near the top and again near the bottom, that the top is apparently considerably hotter. This is because the upper part of the radiator has less moisture on the walls.

Live steam passing through a reducing valve is dried and generally slightly superheated, and it is evident that more heat will be given off by a unit of radiation supplied with this dry steam than would be the case if supplied with wet exhaust steam.

In the case cited by Mr. Hoffman in the issue of Jan. 18, pages 88 and 89, the difference in the amount of

steam drawn from the boilers may have been because it necessarily takes more steam to maintain a constant pressure on radiators condensing steam efficiently than it does on the same radiators working inefficiently, therefore more heat was given off by the radiators when the engine was idle than when running. It may be said that if more heat was given off with the engine idle, then the building would have been warmer, but temperature conditions may easily depend on other circumstances not considered here.

I doubt if the pulsation of the engine exhaust has any great effect on general results, although it may be that the intermittent flow tends to carry along with it water that would be drained out if the flow was constant. It is also true that, as the pressure is applied to radiating surface, in part at least, against dead ends, as these dead ends are approached, flow decreases and the action becomes an alternate compression and expansion, which will affect the constant passage of heat if that action is at all pronounced.

An experience that I had with wet steam may be of interest. A group of hospital buildings is supplied with steam at 85 lb. pressure through a 4-in. underground line 1,700 ft. long. The line is poorly insulated, and there is considerable condensation. A 40-hp. portable boiler was set temporarily outside the laundry building to furnish steam while repairs were being made to the line.

It was found in operating a large motor-driven steam-heated mangle that steam at 70 lb. pressure from the temporary boiler would do better work than steam at 85 lb. pressure from the uncovered steam line with its considerable percentage of moisture.

This does not look reasonable, but it was demonstrated repeatedly, with a steam gage connected directly to the mangle, that shutting off the supply at 85 lb. pressure from the underground line and turning on dry steam at 70 lb. pressure increased the efficiency of the machine in every instance. Opportunity was not afforded to obtain accurate data, other than the foregoing, but I am of the opinion that a comparative test would show very interesting results. FRED. E. UNDERWOOD.

Jamestown, N. Y.

Explosion in an Ash Tank

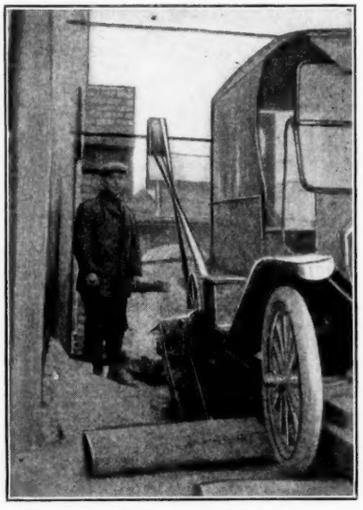
Those acquainted with the vacuum ash-handling system know the general layout and are aware of the fact that the large ash tank is usually provided with plates that are merely set on top of the tank and are free to blow away before the pressure inside the tank becomes dangerous. Before they enter the tank the ashes are usually wet by water admitted to the ash duct at the tank through ½-in. or 1-in. pipe.

Recently the ash tank of our system exploded, doing little damage to the tank, but seriously injuring a man who was on it at the time. I would like to have *Power* readers who are familiar with this type of system explain what kind of gases form in the tank and how they are likely to be ignited and cause an explosion. After the accident we found that the pump that supplied water for the ash duct had been shut down for a number of hours and that most of the ashes handled by the system that day had not been watered. L. C. KRAMER.

Berlin, N. H.

Auto Furnishes Power When Engine Breaks Down

Recently, at the National Synthetic Works, Keasby, N. J., the boiler tubes leaked so badly at 2 o'clock in the morning that the plant had to be shut down. To stop the plant long enough to make repairs would mean a loss of about $25,000. The master mechanic, who lived close by, was called out of bed to try and get the plant running. Seeing that it would take a day or two to get the boiler ready, he contemplated the fitness of the 22½-hp. automobile which the company used for making deliveries. He then told the night superintendent that he would take a chance and hook the auto to the mainshaft. Accordingly the car was set up on wooden blocks as shown, one tire taken off and the rim filled with wadding and wrapped with two rolls of insulation tape to hold the wadding. The machine drove the main shaft 152 r.p.m. for 70 hr., or until the boiler was back in service. A loss of $25,000 was avoided, and the master mechanic received a present of $100 for his ingenuity. WILLIAM J. KEATING.



FORD AS EMERGENCY POWER PLANT

Perth Amboy, N. J.

Should Ammonia Compressor Valves Be Closed?

In the issue of Feb. 29 I read with interest Morris Ellison's letter on the question of closing the compressor stop valves when shutting down for the night. The last two sentences in the article read as follows: "If the discharge valves are always shut and everyone knows it, they will be opened before starting. If not regularly shut, there is liability of someone starting with them shut."

The approved and safest manner of handling the compressor at such times is to close the suction and discharge valves after having pumped back to zero pressure. Make this a rule. Forget that you may shut down for only half an hour or less. If the suction and discharge are closed and the suction valve is tight, the machine may be started slowly and run full speed without danger, though it will do no work. When a compressor runs for a while the ammonia rods become warm and expand, and if the machine is shut down and either the suction or discharge valves are left open the stuffing-boxes will leak ammonia.

Tightening on the stuffing-boxes, when soft packing is used, will perhaps stop the odor. After starting up again it is natural that the rods will become hot and spoil the best packing if the stuffing-box is not loosened. On the other hand, there are many ammonia compressors packed with metallic packing, which must be left alone.

In one plant we had two compressors, running only one at a time, and even then could afford to shut down for several hours at night. Our custom was to leave the suction and discharge valves open. The compressor stuffing-boxes were packed with soft packing. The suction and discharge valves (not stop valves) in the compressor were in first-class condition, and one was not annoyed by leaky stuffing-boxes when the system had been pumped back properly. One evening the frost had come back heavily just before the machine was stopped, and leaky stuffing-boxes gave the engineer trouble. Instead of pumping back once more, he decided to tighten the stuffing-boxes. As he was not accustomed to do this, he probably had forgotten that the stuffing-box had left-hand threads, and of course he loosened instead of tightened the packing. When he was relieved, he reported to the other engineer that he had tightened six turns on one of the stuffing-boxes. In the morning, when the engine was started, the engineer on duty loosened the stuffing-box as much as he thought his partner had tightened it, with the result that the gland came off while the machine was running. The engineer managed to stop the machine, but found it difficult to shut the suction and discharge valves. A considerable amount of ammonia was lost. W. L. KEIL.

Philadelphia, Penn.

Under the heading "Should Ammonia Compressor Valves Be Closed?" Mr. Ellison in the Feb. 29 issue raises the question of how the stop valves should be left when the machine is shut down for the night. The best method is to shut off the liquid valve at the receiver a little while before the machine is shut down and pump the expansion coils and liquid line down to zero, or at least until the machine gets thoroughly hot. Now shut the water off the condenser and stop the machines, shut the valve in the discharge line at the condenser, open the discharge check-valve bypass, close the suction stop valve and open the bypass or cross-connection from the compressor discharge to the suction line, letting the gas in the discharge line as far back as the condenser escape into the suction pipe, reducing the pressure to that of the suction side. Now close the discharge check-valve bypass and the discharge stop valve. Leave the valve in the bypass or cross-connection open until the machine is started in the morning.

In this way there can never be more than suction pressure on the machine. There will be three valves in the discharge line between the condenser and the machine, and one of these will generally hold, preventing leakage from the condenser to the suction side through the machine. If a careless operator forgets to open the valves before starting in the morning, the open bypass valve will give sufficient relief to prevent damage and the whistling of the discharge through the restricted passage will give warning of the condition. This may seem rather elaborate to some operators who are accustomed to shutting down the machine the last thing before going home and then hurriedly leaving as soon as the machine stops; but this way takes but little more time, and there is no danger of an accident and no trouble with leakage.

The suction stop valve should always be closed as well as the discharge valve, because there is just as much danger of doing damage by leaving this valve wide open when starting as there is by leaving the discharge valve shut. Modern compressors all have relief valves for overpressure, but if the suction valve is left wide open when the machine is started, there may be in the suction line a slug of liquid which will be swept along in a body into the compressor. This slug would put a strain on the whole machine and might blow a gasket or start a serious leak somewhere in the system.

Chicago, Ill. THOMAS G. THURSTON.

Feed-Pump Packing Trouble

On taking charge of a power plant a few months ago, I found that there had been some difficulty in keeping the stuffing-box at the steam end of the boiler-feed pump packed. High-grade packing held for a short time, but soon began to blow. One morning I found that the stuffing-box was cracked. A new box and packing were ordered, but when the pump was put in service again the same thing occurred.

I then took out the piston and found that the rod was worn $\frac{1}{16}$ in. smaller in diameter at the center than at the ends, so that the large part put too great a strain on the packing and stuffing-box and caused all the trouble. A new rod of course fixed things. V. O. STEENROD.

Lincoln Ridge, Ky.

Grinding in a Counterbore

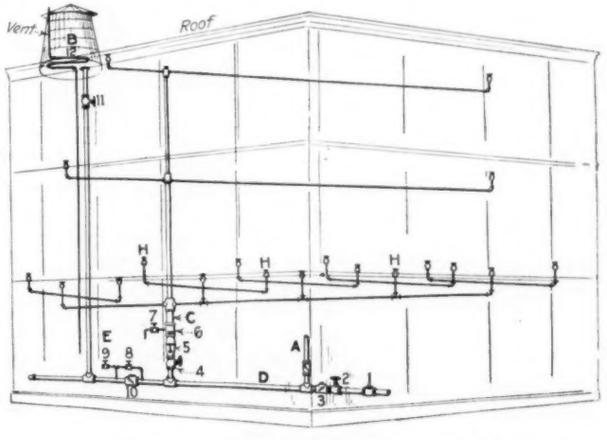
On page 319 of the Mar. 7 issue of *Power* there is an illustrated article on grinding in a counterbore that is all right. My way of doing such a job requires but one man. I take a small portable motor with a flexible shaft hitched to it, about 8 ft. long, and an emery wheel 4 in. dia. by 1 in. wide. The job can be done with one man in one hour.

New Bedford, Mass. E. D. MAYNARD.

Dry-Pipe Sprinkler System

Most modern buildings, whether constructed of wood, brick or reinforced concrete, have sprinkling systems, and the one in most common use is the dry-pipe system.

The reason it is so called is because the pipes are dry throughout the building until called into service and



TYPICAL SPRINKLER PIPE SYSTEM

there is no danger of freezing as in the wet system—so-called because there is water in the pipes at all times. The operation is easily understood by reference to the illustration. The pipe *C* and all its branches are filled with

air at a pressure sufficient to equal that of the supply water (25 to 50 lb.) and should this pressure be relieved in any manner—for example, a fire melting off some of the fusible heads marked *H*—the air pressure would then be relieved and trip the automatic valve 5, then water would flow from *D* into *C* and the branch line through the sprinkler heads to automatically extinguish the fire. This is a simple operation and requires only a few seconds, but there are a great many valves in connection with an arrangement of this kind that may fail to operate and defeat the object of the system.

The function of each valve is as follows: No. 1 is the main cutoff in the street. No. 2 is just inside the building and should be an indicating valve—that is, it should show whether open or closed. No. 3 is a horizontal swing check valve and is always open when the pressure from the street exceeds that in *D*, but should the street pressure fall below the pressure in *E*, then check valve No. 10 opens and No. 3 closes and keeps the water in the gravity tank *B* from escaping into the street main. As soon as the street pressure is again restored, No. 3 opens and No. 10 closes and keeps tank *B* from overflowing.

Check No. 10 has a bypass around it, as shown, for the purpose of filling the gravity tank *B*. No. 9 is a gate valve to drain the tank and piping.

Gravity tank *B*, which is above the roof of the building, has a heating coil (12) in it to keep the water from freezing, and this coil is furnished with either exhaust or live steam as desired. Some of the more modern installations have a steam jacket around pipe *E* in the basement and heat the water in that way.

Pipe *A* is a connection to the system for fire engines or hydrants, and *X* is a check valve to keep the pressure in *D* from forcing water back through *A*.

The defects in the system are these: Mud settles along in *D* and when check valves 3 and 10 operate, they do not close tight and the gravity tank either overflows or empties. These checks have to be taken out often and cleaned. There are a great many makes of automatic valves like 5, and all of them have good points and some defects, making the valve require much more attention than it should. For example, one valve requires half a day to renew the gasket. On another the ground joint on the valve stem doesn't close tight when the valve trips, causing water to flow all around the outside of the valve.

Any valve or check connected to or with No. 5 must be sealed with water to prevent the air from escaping. The first time I reset a valve, I didn't know enough to seal it and had trouble, as valve No. 7, which drains the system into the sewer, would not hold tight. Check valve No. 6, if there is one, must also be sealed with water. In some systems this check is eliminated by the peculiar construction of valve 5.

Some of the things that must be watched for are pockets in the lines, due to the building settling, which will hold water until it freezes, also air leaks due to settling or other damage. I always locate small leaks by tripping valve 5 and letting the system fill with water, which either closes the leaks or indicates them. This cannot be done in freezing weather, consequently every fall I make sure that the system is tight and that the heating in connection with the gravity tank is in first-class condition. The system should be examined daily to see that heads are not blocked so that they are inoperative in case of fire. Twice a year a head should be melted and the apparatus tested.

Some systems use a pressure instead of a gravity tank, but this makes little difference in the operation. All the pipes and the tank on the roof, whether steel or wood, should be painted once a year or whenever necessary.

The best system is useless if not given proper attention and kept in condition. H. G. Schuler.

Kansas City, Mo.

Low-Pressure Steam for Dyes

I would like to see some statements in *Power* from master mechanics and chief engineers of colored-textile plants as to the relative values of high- and low-pressure steam for boiling dye in vats.

Boss dyers and dyehouse chemists are usually prejudiced against low-pressure steam even if the temperature is shown to be high enough for their purpose—superheated above the temperature due to the pressure to some extent.

Amsterdam, N. Y. Harry H. Gordon.

Groaning in Steam Pump

I wish to thank those who so kindly sent their suggestions in answer to my distress call, and as a result I received a personal letter from Mr. Fisher, of New York, telling of trouble he had some 35 years ago and what he had done, and I found mine to be the same.

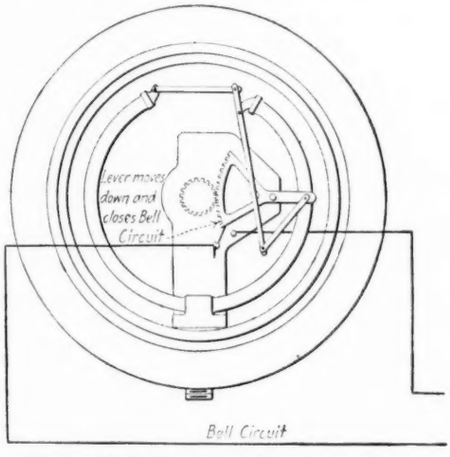
The valve-stem packing had become hard and caused the groaning. Soft packing screwed "finger tight" relieved the strain, and I now have a quiet running pump.

Keokuk, Iowa. Emile Blondet.

Pressure Limit Alarm

In connection with a battery of digesters it was desirable not to exceed 50 lb. steam pressure, and safety valves were found undesirable because of the loss of steam.

We arranged a pressure-limit alarm made out of a steam gage, as shown in the illustration, to close the



ELECTRIC ALARM CONNECTED TO STEAM GAGE

circuit to an electric gong, which gave the alarm when the desired limit was reached. This proved to be a very reliable "watch dog" against excessive pressure and avoided the loss and annoyance incidental to escaping steam.

Philadelphia, Penn. W. Sailes.

Inquiries of General Interest

Angle of Safety-Valve Seat—Why does a safety-valve seat have an inclination of 45 deg. to the axis of the valve? W. H.

Safety valves are subject to wear from pounding on their seats and are beveled for greater facility in grinding. The angle of 45 deg. is selected for convenience in uniformity of construction and of coefficient of discharge.

Lead Gasket a Dangerous Makeshift—On a small boiler, where the tapping of the feed connection below the water line has rusted out, can lead gaskets under check nuts, inside and outside of the boiler shell, be depended on for making a permanent joint? J. C.

Lead gaskets cannot be depended upon, as they become permanently compressed from expansion of the boiler shell and are very likely to leak badly after the shell contracts from cooling. A connection of the kind should not be made below the water line, as leakage may cause dangerously low water in the boiler without warning.

Standard Unit of Refrigeration—What is the standard unit of refrigeration? A. Z.

In this country, the unit of refrigeration is the number of B.t.u. that must be abstracted from one ton (2,000 lb.) of water at 32 deg. F. to produce one ton of ice of the same temperature. As the latent heat of ice, or the amount of heat required to melt a pound of ice at 32 deg. F. into water at the same temperature, is 144 B.t.u., the unit of refrigeration is 2,000 × 144, or 288,000 B.t.u. The employment of 228,000 B.t.u. as the unit of refrigeration was suggested by the American Society of Mechanical Engineers in 1906, and this value has since been generally accepted.

Smoke as an Indicator of Efficiency—To what extent is dense smoke issuing from a boiler smoke-stack an indication of inefficient firing? M. L. D.

In burning oil as fuel, dense smoke may indicate that a very considerable proportion of the fuel is going to waste from imperfect combustion; but in burning coal a smoky chimney does not necessarily indicate serious inefficiency of firing, as the losses due to visible smoke seldom exceed 2 per cent. Dense clouds of smoke may result from the operation of a furnace with minimum air supply and incomplete combustion that will give a higher evaporation per pound of fuel than where the furnace is made smokeless by a larger excess of air, causing much greater losses by the heat carried away in the chimney gases.

Discharge of Pump—Allowing for 7 per cent. slip, how many gallons of water should be delivered per hour by a 6x8-in. double-acting pump with a piston rod 1⅛ in. diameter when making 160 single strokes per minute? B. H.

The gross area of the piston would be $6 \times 6 \times 0.7854 = 28.274$ sq.in. As the cross-sectional area of the piston rod would be $1\frac{1}{8} \times 1\frac{1}{8} \times 0.7854 = 0.994$ sq.in., the effective area of the rod side of the piston would be $28.274 - 0.994 = 27.28$ sq.in. and for 160 single strokes of the pump, or 80 discharge strokes per minute in each end of the cylinder, the displacement would be $(28.274 + 27.28) \times 8 \times 80 = 35{,}554.56$ cu.in. per min. A gallon is 231 cu.in., and with 7 per cent. slip the pump would deliver

$$93 \text{ per cent. of } \frac{35{,}554.56}{231} \times 60 = 8{,}588.5 \text{ gal. per hr.}$$

Rotary Converter vs. Motor-Generator Set—What are the relative advantages of a rotary converter and of a motor-generator set for changing direct current to alternating current for a capacity of about 100 hp.? W. A. C.

A rotary converter is the more efficient, weighs less and generally costs less. However, the ratio between the direct- and the alternating-current voltages is fixed, being 0.71 for single-phase, two-phase and diametrically connected six-phase machines, and 0.61 for three-phase and double-delta-connected six-phase machines. If any other ratio is desired, it is necessary to employ transformers on the alternating-current side. Where the power factor on the alternating-current system is low, the employment of a synchronous motor-generator set provides means for raising the power factor, and under certain conditions a closer voltage regulation is possible with a motor-generator.

Casehardening Mild-Steel Valve Stems—How can mild-steel valve stems be casehardened? J. C. T.

Casehardening can be done by heating the piece to a dull-red color, and after covering with pulverized crystals of cyanide of potassium (prussiate of potash) the surfaces that are to be casehardened the operations of heating and coating are to be repeated. The heating should be performed gradually and evenly so as not to burn or scale any finished surfaces of the valve stem. After the piece has been cooled in the air almost to a black heat, it is to be cooled in water by plunging vertically. The cyanide is a violent poison and should be handled accordingly. A good way to coat the heated valve stem is to roll it over the pulverized cyanide when spread out on a flat surface.

Another method of casehardening, less convenient but unattended by danger from poison, is to heat the piece packed in a muffle with a carbonizing material, such as a mixture of equal parts, by measure, of granulated raw bone and granulated charcoal. The muffle can be a piece of iron pipe large enough for packing the piece so it will not be closer than about 1 in. to the sides of the muffle. Several steel test wires extending the full length of the muffle can be packed in it along with the piece to be casehardened. By withdrawing the test wires at intervals, it can be determined when a red heat has been obtained the fuel length of the muffle, and when thus heated, the piece to be casehardened can be withdrawn, air-cooled and hardened by plunging in water in the same manner as in casehardening with cyanide of potassium.

Submerged-Tube Vertical Boiler—What difference is there in the arrangement of the tubes in an ordinary vertical boiler and in a submerged-tube vertical boiler? H. D. W.

In the ordinary form of vertical fire-tube boiler the tubes extend from the firebox tube sheet to the tube head in the upper end of the shell. The upper ends of the tubes extend a upper end of the shell. The upper ends of the tubes extend above

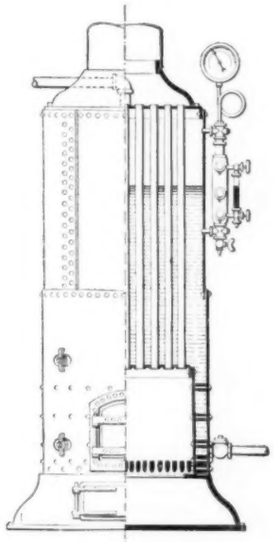


FIG. 1. ORDINARY VERTICAL BOILER

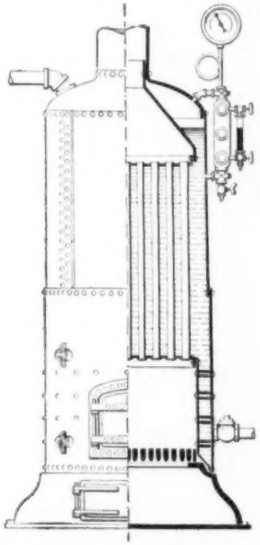


FIG. 2. SUBMERGED-TUBE VERTICAL BOILER

the water line, as shown in Fig. 1, and are thus exposed to the high temperature of the flue gases on one side and to steam on the other, and are likely to become overheated and leak from unequal expansion between the tubes and the head or shell to which the tube sheet is attached. In a submerged-tube vertical boiler the upper flue sheet, as shown in Fig. 2, is below the water line, with the shell extended above the upper tube sheet, forming a water and steam space around the smoke uptake.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Efficiency in the Utility Plant*

By Charles Brossmann†

In the last few decades there has been a wonderful growth in the utility plants of every description, including light, water, heat, gas and other types of public-service plants, whether private, municipal or a combination of both. By utility plant is meant any plant that supplies service and that is supported either directly or indirectly by the taxpayer. The earlier plants were naturally without the refinements found in the modern ones of today; as a rule a pump was a pump, a boiler was a boiler and an engine was an engine. Generally no great importance seemed to be attached to the question of economy, especially in the medium- and smaller-sized plants, and today one sometimes finds that this still holds.

Economy in its real sense is not generally practiced in this country as it should be. This may apply as well to privately operated utility plants as to public, but the private plant is a quasi public institution and is not so open to criticism or investigation as the municipal plant, except by legislation.

In the purchase of new equipment, requirements should first be determined, and all available records made as to the loads and duties of the old equipment. Then when requirements and limitations are fully known and properly charted, bids can be intelligently received.

After receiving bids, in order to purchase economically, the duties and guarantees and other important data should

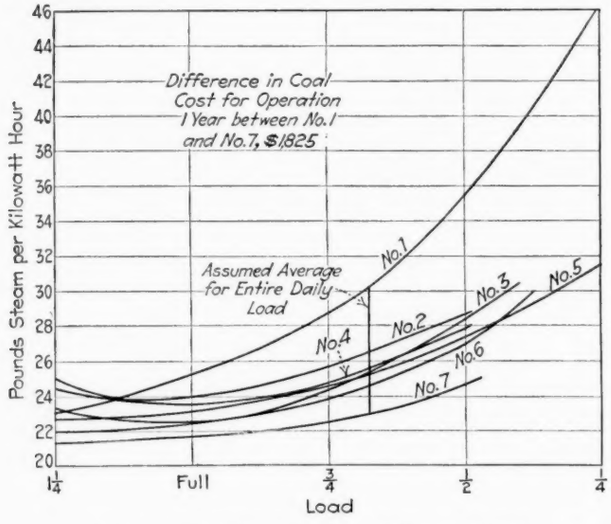


FIG. 1. CHARTS OF A 250-KW. TURBINE

be fully tabulated and charted, thus making a direct comparison. Fig. 1 shows the charting of 250-kw. turbine generating units. The bids were tabulated after the bidder was asked to give guarantees and filled a data sheet with the required information. After all data were received, tabulated and charted, a proper comparison could be made. On this chart the average load condition for the day would be at about five-eighths of the capacity of the machine; this shows a difference of 7 lb. of steam per kilowatt, and at a 24-hr. load, an evaporation at the boiler of 6 to 1 and coal at $2.50 per ton, the difference in fuel cost is $1,825 the first year on this small unit.

To purchase economically is not altogether a question of price. The prospective buyer should ask for bids and full data and then properly analyze them, giving due consideration to the reputation of the bidder and as to whether he is making bona fide or "flash-test" guarantees or guarantees that cannot be met.

Economy does not mean getting the lowest possible prices, but rather the highest result with the least expenditure. Neither is the lowest-priced engine, boiler, pump or other apparatus always the cheapest, nor is coal at the lowest ton price always the most economical to use. They must all be analyzed for the special conditions they are to operate under, and unless properly determined, there is likely to be a loss.

Take the purchase of fuel. The Table shows some coal bids. The coal with the highest number of heat units is not

*From a paper read at the February meeting of the Indiana Engineering Society and the Indiana Sanitary and Water Supply Association, Indianapolis, Ind.

†Consulting Engineer.

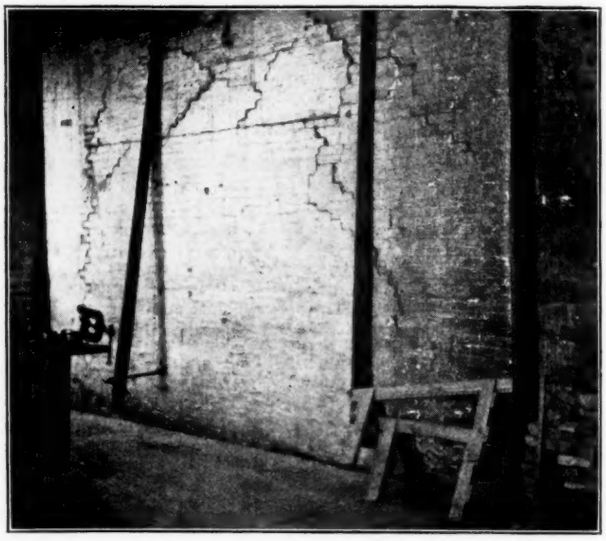


FIG. 2. CRACKED BOILER SETTING

the best, and the lowest in price is not the cheapest. Of the two lowest-priced coals listed, although one is good as to heat value, both have the highest sulphur and moisture and ash content. Each is $1.75 per ton. There are two coals at $1.80 per ton—one giving 14,000,000 heat units, the other only 11,600,000, for $1. This shows that it is impossible to tell by the price alone or by the B.t.u. per pound alone; all factors must be considered.

In some plants a fireman is looked on as a coal shoveler, and in some the engineer as the man that starts and stops the engine. It takes some thought to burn ten or twenty or thirty thousand dollars' worth of coal a year and burn it right, and if a fireman or engineer can save 5 or 10 per cent. or more of it, he is worth more in proportion to what he saves.

Getting down to your own plant, are the boilers clean and all brickwork tight and without leaks, or cracked like Fig. 2. Is the baffling tight and gases not short-circuited in water-tube boilers? Are you using the proper draft for the best working conditions, and do you use your dampers instead of the fire- and ash-doors, thus preventing excess air leaking? Are your draft regulators properly set? Are the combustion chambers of the boilers clean, or are the tube spaces and breeching stopped up with soot or ashes? Are all exposed pipes and heating surfaces covered properly? Are blowoff valves tight and not blown off excessively? Is the feed-water heater clean and giving maximum temperature? Are all wastes, steam traps, etc., tight and without excess leakage? Do you keep a log and understand what it means? Is there any great loss of pressure between boiler and engine? Is the steam dry? Are engines and pumps operating at maximum economy? Do pistons leak? Are the valves properly set? Have you indicated these lately? Is there excessive slip to the pump? Is exhaust back pressure at the minimum? Are you getting maximum or proper vacuum from your condenser and maximum hot water to the hotwell? Do you

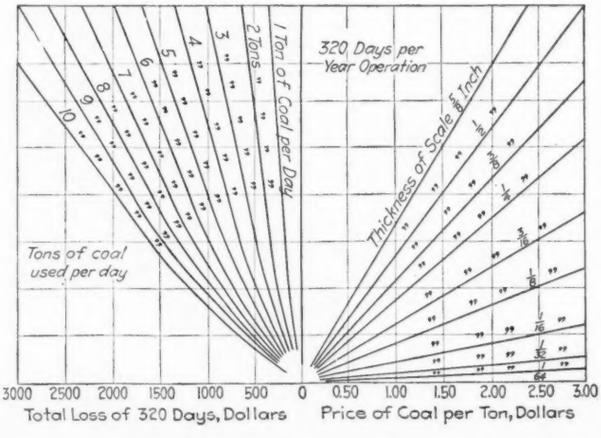


FIG. 3. CHART SHOWING FUEL LOSS DUE TO SCALE

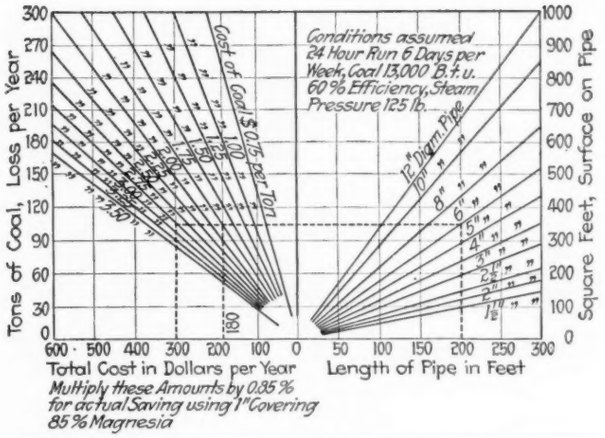

Conditions assumed
24 Hour Run 6 Days per Week, Coal 13,000 B.t.u. 60% Efficiency, Steam Pressure 125 lb.
Cost of Coal $0.75 per Ton
12" Diam. Pipe
10" " "
8" " "
6" " "
5" " "
4" " "
3" " "
2½" " "
2" " "
1½" " "
Tons of Coal, Loss per Year
Square Feet, Surface on Pipe
Total Cost in Dollars per Year
Length of Pipe in Feet
Multiply these Amounts by 0.85 % for actual Saving using 1" Covering 85% Magnesia

FIG. 4. CHART SHOWING LOSS DUE TO UNCOVERED STEAM PIPES

know how much scale you have in your boilers and that you are operating with the least amount of scale?

The chart, Fig. 3, will give an approximate idea of fuel loss due to scale. For example, ⅛ in. of scale will make a difference of about 15 per cent. on fuel increase. With coal at $2 a ton and using 10 tons per day ⅛ in. of hard scale will mean a loss of about $1,000 per year in coal.

The chart, Fig. 4, shows the losses due to uncovered steam pipe. For instance, 200 ft. of uncovered 6-in. pipe, with coal at $2.75 per ton, means a loss of $300 per year, and 85 per cent. of this could be saved with a proper covering.

Do you know what leaky boiler blowoff valves cost, and have you realized that a blowoff valve on one boiler with a leak equal to a ½-in. diameter hole and leaking continuously, with steam at 150 lb. pressure, coal at $2 a ton and water at 5c. per 1,000 gal., means a yearly loss of about $300? If the leak is smaller or larger, the coal loss will be in proportion. See chart, Fig. 5.

Fig. 6 shows two sets of readings taken from two different plants giving simultaneous readings of draft and CO_2. Under No. 1 the average CO_2 was 4 per cent., showing a preventable fuel loss of 32 per cent. This boiler was running

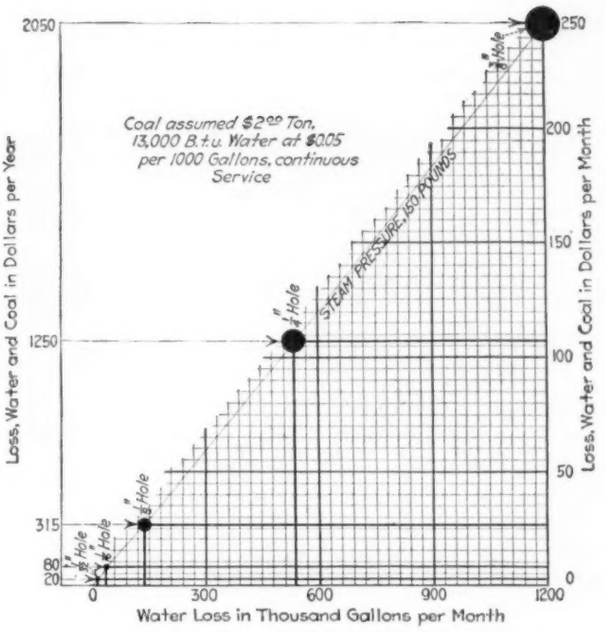

Coal assumed $2.00 Ton, 13,000 B.t.u. Water at $0.05 per 1000 Gallons, continuous Service
STEAM PRESSURE, 150 POUNDS
Loss, Water and Coal in Dollars per Year
Loss, Water and Coal in Dollars per Month
Water Loss in Thousand Gallons per Month

FIG. 5. COST OF LEAKY BLOWOFF VALVES OF VARIOUS AMOUNTS

In No. 1 boiler plant the efficiency for the entire year was not averaging over 50 per cent.; No. 2 boiler test showed close to 68 per cent. This boiler was fitted with a damper regulator, and on No. 1 the damper was not bothered.

Similar conditions occur in many plants—though not all of them at their worst in every plant or in most plants—and they are not confined to the municipal plant alone, but are found in private ones as well, and in many a little of each of the faults make a big total or perhaps one or two losses are really bad.

In one plant the tubes of the surface condenser were clogged so it could not be used. Another had thrown out a surface condenser because the operating engineer said it did no good. A third was operating with the feed-water heater out of service because it was too much trouble to clean it. Still another was being run with a damper regulator connected backward; consequently the boiler could not carry the load. In another, changes were made to the draft damper resulting in a cut of 8,000 lb. per day in the coal consumption. Another plant was pumping all the water twice, when a little pipework would have given the same results with one pumping and a big saving in fuel.

ANALYSIS OF COAL FOR LIGHT AND POWER CO.

Proposition	Price per Ton	Fixed Characteristics per Pound: B.t.u.	Fixed Carbon, Per Cent.	Volatile Matter, Per Cent.	Ash, Per Cent.	Sulphur, Per Cent.	Moisture, Per Cent.	Loss Due to Moisture in B.t.u.	Actual B.t.u. per Lb., Allowing for Moisture	Addition in Price per Ton Due to Ash Loss	Actual Cost of Coal Due to Ash Loss	Actual B.t.u. per Ton	Number B.t.u. for 1 Cent	Number B.t.u. for $1.00
1	$1.80	12,000	44.64	37.70	8.61	1.35	9.05	1,086	10,914	$0.013	$1.843	21,828,000	118,284	11,828,400
2	1.75	11,800	45.75	34.40	10.20	3.16	9.65	1,138	10,662	0.051	1.801	21,324,000	118,000	11,800,000
3	2.30	14,700	57.00	35.15	6.00	0.60	1.25	184	14,516	0.03	2.33	23,032,000	124,600	12,460,000
4	1.80	13,596	52.26	36.40	6.69	0.64	4.01	545	13,051	0.0334	1.8334	26,102,000	142,478	14,247,800
5	1.75	13,110	44.63	37.20	7.89	2.80	10.28	1,348	11,762	0.0394	1.8394	23,524,000	127,889	12,788,900
6	2.45	13,600	59.00	33.00	8.00	0.75	0.1	136	13,464	0.04	2.49	26,928,000	108,144	10,814,400

with 400 per cent. excess air, and the fire was light and burning less than 8 lb. per sq.ft. of grate surface. On No. 2 the CO_2 averages 11.6 per cent., the preventable fuel loss was less than 3½ per cent., and there was only 80 per cent. excess air. The coal burned averaged 35 lb. per sq.ft. of grate. The draft on No. 2 will average not higher than on No. 1.

In boiler No. 1 the draft was out of proportion and too strong, firing was at too long intervals; there was excess air leakage, and the grate surface was not suitable for the coal.

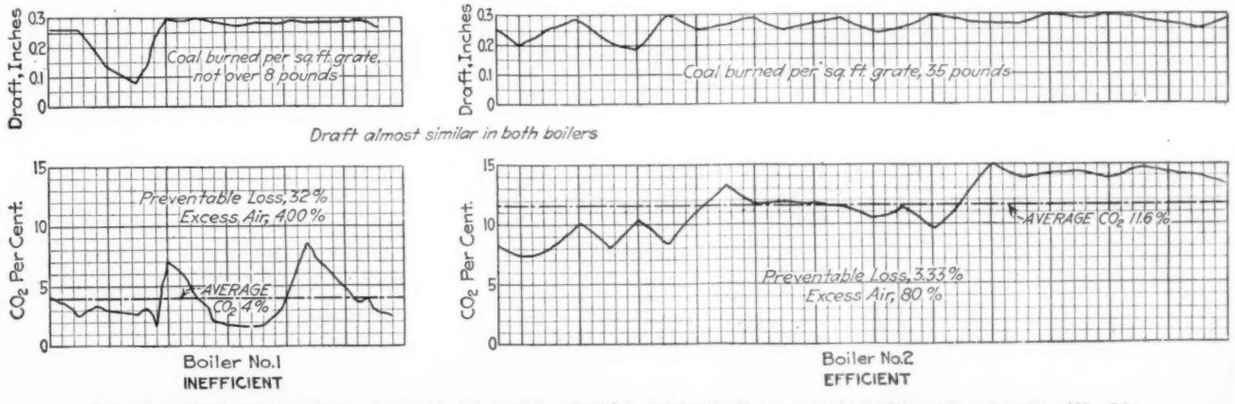

Draft, Inches
Coal burned per sq ft grate, not over 8 pounds
Coal burned per sq ft grate, 35 pounds
Draft almost similar in both boilers
CO2 Per Cent.
Preventable Loss, 32% Excess Air, 400%
AVERAGE CO2 4%
AVERAGE CO2 11.6%
Preventable Loss, 3.33% Excess Air, 80%
Boiler No.1 INEFFICIENT
Boiler No.2 EFFICIENT

FIG. 6. TWO READINGS OF TWO PLANTS, GIVING SIMULTANEOUS READINGS OF DRAFT AND CO_2

Many improvements and new inventions, some quite radical, have taken place in prime movers, generating units, boiler equipment and methods of operation. Coincident with available improved economy in power-plant work has been the revolution in thought leading to legislation and regulation of public utilities. The demand for lower rates has been more or less coincident with plant improvement and increased efficiency of operation and management; and right here may I mention one instance of improvements in generating units? The 30,000-kw. unit recently installed at the Seventy-fourth Street Station, New York, as compared to the old Manhattan-type engines installed in 1901, on 24-hr. service would effect an approximate saving of 240 tons, or $700 per day, based on coal at $3 a ton.

In order to operate indefinitely in competition or under legislative control, there must be adopted in ever branch, methods that replace inaccuracy with definite and accurate knowledge, all economic waste must be systematically eliminated and all departments brought into proper and harmonious coördination.

⋇ ⋇

Power-Station Buildings

SYNOPSIS—A review of the many things which must be considered in the design of a modern power-plant building with particular reference to foundations, smoke-stacks, coal-handling equipment, intake crib and tunnel and architectural adornment.

On the evening of Mar. 6, before the Western Society of Engineers, James N. Hatch presented an unusually interesting paper on the subject of "Power Station Buildings." During the course of the lecture the speaker showed 73 lantern slides illustrating various features relative to the topic of the evening. He made no attempt to follow out in detail the design of the many parts that make up a power station, but presented some interesting features of the planning of such structures in a broader aspect.

In the early uses of electricity before long-distance transmission of energy had developed, the amount of power required from any one station was small. Therefore the requirements in the way of buildings for housing the generating machinery were simple. Today, however, with the centralization of power in large units, the problem of working out a proper design for the building and foundations has become an important branch of engineering.

It is sometimes argued that anything in the way of architectural adornment in a power-station building is a waste of money, but the truth of this assumption is to be seriously questioned. The stability and success of any enterprise and the character and ability of the men behind it are judged consciously or unconsciously by the appearance of the physical property. This is true of power stations in a marked degree, and as the building cost is a small percentage of the investment in the entire station, the extra expense required to add a few artistic touches to the exterior and interior finish is so small as to be almost insignificant. For instance, suppose the entire station represents an investment of $2,000,000. The building portion would probably cost in the neighborhood of $300,000, and the difference in cost between a building entirely plain and unadorned and a building with a neat artistic appearance would not involve over $10,000 to $15,000, which would represent something like ½ of 1 per cent. If the enterprise depends on selling stocks and bonds for its finances, this small investment may pay for itself many times over.

PRELIMINARY STUDIES

The layout of the machinery is the fundamental determination in planning a power station, but if this is made arbitrarily without any special reference to the building design, it often becomes difficult, if not impossible, to design a neat well-balanced building to inclose the machinery. For any power-station design it is desirable that the mechanical, electrical and building engineers work closely together so that the machinery and the electrical layout can be arranged with some reference to the building features. To accomplish this it is generally necessary to make a number of preliminary studies and then by a process of elimination and rectification work out a design that will best serve the end of all. As soon as a design that will determine the main features of the building is tentatively decided upon, the work of the real design of the building can be started.

The first work is to draw up a skeleton of the building and work up two or three elevations. From the skeleton a good idea can be gained as to where principal loads will be concentrated on the foundation and as to where columns will be located. The elevations will serve to determine the location of windows, doors and other openings. By the time three or four such skeleton drawings have been worked out, some interferences have probably developed that could not have been foreseen, and that will require some adjustment in the mechanical or electrical layout. A little trimming here and there will accomplish much, and after one or two more conferences among the engineers representing the different parts of the structure, the actual work on the design of the building can go forward.

One of the first things to be decided is the kind of foundations that will be required. The site for a power station may be on the lake shore, where the high waves and shifting sands make a problem of one nature; or on salt water, where the corrosive conditions are severe; or on the bank of a river, where the rise and fall of the stream between extreme high and low water is 60 or 70 ft.; or it may be along the Missouri River, where the quicksands are extremely treacherous, or along the Mississippi River, where the foundations will be on solid rock. If the site of the proposed building is in a city or town, it if often possible to gain considerable knowledge from the investigation of structures that have been built in the vicinity and from an inquiry of the nature and character of the underlying soil. But it often happens that a power station is built far away from any other building and the engineer in charge must make all preliminary determinations from his own investigations.

Generally it is necessary to have a number of borings made, and in addition it is often advisable to have a few test holes dug down as deep as the earth can be conveniently excavated. These test holes will afford a means of examining the nature of the different strata of earth. From this examination a good idea can be obtained of what loads the earth will safely bear per square foot. Whether the foundation is simply to rest upon the earth or must have piles or caissons is a matter to be decided by the building engineer from his investigation of the soil and surroundings.

It is generally necessary to bring a large intake and discharge tunnel into the center of the building. This complicates the foundation problem. If the underlying material is solid rock, the tunnel can be driven through it, but if it is sand and gravel to an indefinite depth, the problem is much more difficult, particularly if the tunnel must be sunk to a depth of 50 or 60 ft. so that it will always be below the low-water level of the river on which the station is located.

FOUNDATION MATERIALS

Next to solid rock, sand and gravel are about the best materials upon which to place a foundation for a heavy building, but they must be confined and must not be undermined by deeper foundations near-by. Clay is always a treacherous substance on which to place a heavy foundation, especially if it is subject to alternate saturation and extreme dryness. It is difficult to judge of the load that clay will safely bear, as it seems that almost any clay is subject to some compression, which, although taking place slowly, may continue for many years and become a significant amount in time.

If, upon an examination of the site, the engineer thinks that the underlying materials will not carry the building safely, he must resort to some method of increasing its bearing power sufficiently to make it safe. If there is a hard underlying stratum at a reasonable depth, it may be determined to drive piles, but if the underlying materials do not become solid until a depth of 80 or 100 ft. is reached, so that piles cannot be utilized, it may be desirable to use so-called caissons. These are made by digging wells 5 to 8 ft. in diameter to a solid footing, and then filling with concrete and distributing all loads to them.

If a heavy building is to be placed on soil of a quicksand nature where piles would not be practicable, a method considerably used is to place the entire structure on a reinforced-concrete mat, generally 5 or 6 ft. thick and thoroughly reinforced in both directions, both top and bottom, in the hope that if there is settlement it will be so uniform over the entire building as not to be noticeable. One serious difficulty with this arrangement is to know what is going to happen where the tunnel joins the mat. If the entire mat settles

considerably, it is likely to break away from the tunnel where the two join.

It is clear that the determination of the style of foundation best adapted for any particular location is a problem of itself and must be solved for that particular site and the particular building which is required.

As soon as the general arrangement of the machinery has been decided upon and a skeleton plan and cross-section of the building has been worked out and the elevation of the exterior has been tentatively fixed upon, the detailed location of all walls, piers and columns must be decided, so that the foundation walls and footings can be designed. A fairly close estimate can be made of thicknesses of walls, sizes of piers and outside dimensions of columns just from a study of the skeleton of the building, and a fairly close approximation can be made of what the weight of the machinery will be from the weights of similar machinery used elsewhere. It is therefore possible to figure the load from the roof downward that will be transferred to the walls and columns and piers. A careful schedule should be made of these loads, showing at what elevation they come and what each is from. These should be put on an outline plan of the building and on a cross-section, so that they can be readily checked over and so that if, after more data are received, there are changes required, it will be easily seen how the original assumption will be affected. This loading schedule will be referred to until the building is completed, and should be carefully made and checked. With the schedule completed, the design of the foundation can be undertaken.

Foundation walls and footings for buildings and machinery are made at present almost without exception of concrete. If below the high-water level the basement floor must be carefully built and joined to the walls so that there will be no leakage.

In the modern large station the smoke-stack is frequently carried on a steel structure over the boilers. This has a number of advantages—it permits a saving in land and in the size of the building and allows one uninterrupted row of boilers. The argument against this arrangement is its extra cost. Slides of a number of high stacks resting on steel structures were shown. In some the stack structure is joined rigidly to the building structure and in others it is not connected in any direct way to the building.

POWER-PLANT CHIMNEY FOUNDATIONS

Stacks and chimneys that rest directly on the earth do not involve any special features that need to be dwelt upon. It is necessary to remember that under the maximum wind conditions the earth pressure at the toe of the foundation on the leeward side of the chimney may become as much as twice the average earth pressure over the entire base with no wind blowing. Care must be taken to insure there being no uplift under the toe of the foundation on the windward side.

The choosing of a site for a power station and the whole layout of the plant should be governed largely by the way the coal is to be handled; or in other words, some definite plan for handling the coal should be one of the first things worked out in laying out a power station. Good switching facilities should be planned, with ample room for storing a reserve supply of coal. With a station using 3,000 or 4,000 tons of coal per day, it will be realized that this is an important problem, for even when the station is using directly from the cars, to hold three or four days' supply on hand will require the storage of 300 or 400 cars and the returning of 100 empty cars and 8 or 10 cars of ashes each day. The coal must be unloaded, put through the crusher and then taken by conveyors to the bunkers over the boilers. There are many ways in which this can be accomplished, and the particular method best adapted to any given station will depend largely on the conditions existing there. A number of slides were thrown on the screen, showing several different schemes that have been adopted for different conditions of operation.

Reference was made to the coal bunkers at the Conners Creek plant of the Detroit Edison Co. These are made of steel plate and are lined with a thin tile laid in bitumastic cement. A number of Eastern power stations have concrete bunkers with steel-beam ribs. The main objection to concrete bunkers is their great weight, which makes the steel-supporting structure expensive; also, the concrete becomes pitted and rough so that the coal does not slide well, and it is difficult to keep them from leaking where wet coal is used.

Unlined steel-plate bunkers are the lightest and would be the most satisfactory if it were not for the rusting that is caused by the wet coal. This will gradually eat through the plate and requires the replacing of these plates in ten or twelve years. Steel-plate bunkers with a thin lining are about the best that are known at the present time. Although to the speaker's knowledge none had been in use long enough to fully demonstrate its value, it was his opinion that this type of bunker would prove quite satisfactory.

One of the most difficult features of construction connected with the power station is the building of a water intake and tunnel to convey the water for condensing purposes from the river or other body of water to the interior of the turbine room. The immense quantity of water required daily is probably not generally realized. For instance, a station of 100,000 kw. capacity will require about 288,000,000 gal. per day.

In order to have gravity flow into the station, it is necessary to have the tunnel below low water. This requires that the intake must be at the same depth as the tunnel, and as it is generally out from the shore, a tight coffer-dam must be built, inside which the intake can be constructed and from which the tunnel can be started.

In the speaker's experience the opencut method of building a tunnel for the intake and discharge water has proved the most satisfactory even when the excavation is 50 ft. deep or more, except where solid rock is encountered. In clay soil the opencut method is not generally a difficult one if sufficient care is taken in timbering. In gravel and sand it is in many cases about the only method that can be used, as it is next to impossible to drive a tunnel through this sort of material. Compressed air is likely to be of little use in coarse sand and gravel, for the air will go right through the gravel to the surface and will not hold back the water.

MAINTAINING CLEAR TUNNEL

While it is not necessary that the tunnel should be watertight, it should be substantially so, for if there is much of a leak of water either out or in there is danger of drawing the sand away from under the tunnel and having a settlement that will eventually break it.

Another problem is to keep the leaves and rubbish of all kinds from entering the tunnel. In this connection the speaker made brief mention of stationary screens that could be removed for cleaning and of traveling screens that were automatically washed by a spray of water and need not be removed from the intake except for repair. Some attention was given to the rebuilding of old stations, and a number of slides were presented showing how it had been done in particular cases while the service was maintained.

In conclusion brief reference was made to the artistic design of the power station. While the purely architectural features should be given careful study and the whole design of the station should be made with the architectural scheme in view, still the usefulness or economy of the plant should not be appreciably hampered to carry through some preconceived scheme. In fact, this is not necessary, for a building of good appearance can be worked out in harmony with almost any well-planned machinery layout, especially if the two are worked out together.

DISCUSSION

In the discussion J. L. Hecht was of the opinion that the point of view of the operating man was too frequently slighted when it came to the design of the power plant. Frequently he is able to give valuable suggestions, and any help from this direction should not be overlooked. It is important to make provisions for future unforeseen requirements. In the past few years the growth of many stations has been beyond all expectations, so that whatever provisions have been made are usually inadequate. As a consequence many difficult problems are encountered in taking care of the increased demand on the station. In the design it is well to bear in mind insurance requirements. Spending a few dollars to comply with the underwriters' regulations will generally result in a saving in insurance premiums. Locker and toilet rooms should be arranged for before the station is completed, and proper provisions should be made for storerooms and machine shops; otherwise the quarters eventually secured will be unsatisfactory. In his opinion power station design is a specialty and unless it is undertaken by a competent engineer rather than an architect, the design will usually result in economical waste and more or less unsatisfactory conditions.

C. A. Keller called attention to the great height of power-plant buildings and the depth to which they were carried in the ground. In his opinion the limit has been reached and, following American practice of going to the limit in one direction and then coming back, there will probably be a return to lower buildings. The design has developed to a point where the economizer is placed over the boilers and the stack over the economizer, and coal hoppers of great capacity are installed. Only a few years ago these three things were independent of the structure; now they are connected with it. In European plants they are working away from these great heights by making the economizer part of the boiler and by putting in bunkers of less capacity because

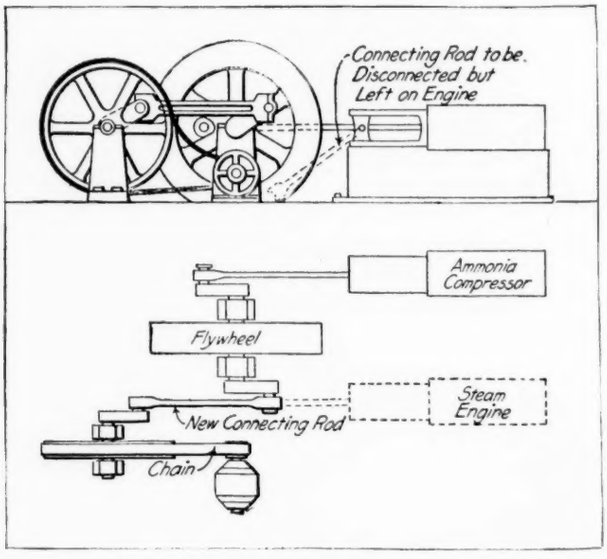
of more reliable coal-handling equipment. In one plant only a two hours' supply is provided. Another diversion in European practice is the use of short stubby stacks in connection with forced draft. In Europe power plants are built with 1 lb. of structural steel for each pound of steam-generating capacity. In this country 5 to 6 lb. of steel is utilized, but it is likely that this exorbitant use of steel will be gradually reduced.

In reply to a question concerning the relative advantage of concrete buildings over steel-frame structures, Mr. Hatch expressed the opinion that concrete structures are more expensive that steel. Even brick walls, when strong enough to withstand the vibration, cost more. Besides, steel offers better facilities for making changes and greater safety in the event of an explosion or other accident. Ordinarily the steel beams will twist or bend, but will not be thrown down in a pile like a concrete structure.

As to the prevalent use of tall chimneys rather than forced draft, it is a matter of choice. Many people do not like the added equipment which forced draft necessitates, and the chance of a shutdown should anything happen to the fan. Chimneys are more reliable, but it is quite likely that there will be a reversion to forced draft because of the increasing use of economizers and the new types of underfeed stokers.

Ammonia Compressors Motor Driven in Summer

Under conditions existing in Chicago it is practicable for the central-station company to serve isolated-plant owners on an off-peak schedule with energy for operating ammonia compressors that during the colder months are driven by



COMPRESSOR PROVIDED WITH MOTOR DRIVE FOR SUMMER

steam. The rate that the company can make for this off-peak service is attractive, and the service itself is of real value to the isolated-plant owner in that it permits him to use his exhaust steam in the winter and yet to discontinue entirely the operation of his steam equipment in the summer, when there is no application for exhaust steam.

For some time the principal drawback to the plan was a mechanical one. Motors could not well be belted to the flywheels of the compressors, because the flywheels used were too narrow to carry a belt large enough to transmit the required power. New and wider flywheels could not be substituted economically, because the existing flywheels revolved in narrow steel-lined concrete pits that could be enlarged only with a great deal of labor. Neither was it practicable to attach gear teeth to the flywheel faces, since space was lacking and since the task of installing the teeth would necessitate discontinuing operation of the compressor for several days.

A thoroughly practicable way of making the off-peak service available was worked out, however, by Nels Joleen, of the Commonwealth Edison Co. As is shown in the sketch herewith, the new equipment needed consists of a slow-speed motor (say 514 r.p.m.) chain-connected reduction gears, a crank and a connecting-rod. With the equipment installed, it is only necessary when electric service is desired to disconnect the engine connecting-rod from the crank, put the new connecting-rod in place and start the motor. The whole change from steam to electric drive can be made by one man in less than thirty minutes when once the equipment is installed.—"Electrical World."

PERSONALS

George S. Cooper, until recently mechanical engineer of the Buckeye Steam Engine Co., of Salem, Ohio, is spending a month or two in California prior to making a new connection.

Nathan Owitz, formerly in the sales department of the Wheeler Condenser and Engineering Co., Carteret, N. J., is now sales manager of the J. P. Devine Co., Buffalo, N. Y., manufacturers of vacuum drying and impregnating apparatus.

Walter Castanedo, for many years New Orleans representative of the Harrisburg Foundry and Machine Works, has been appointed district manager for the Ames Iron Works, of Oswego, N. Y., at New Orleans, with headquarters at 1101 Hennen Building, that city, to take effect Apr. 1.

H. G. Stott, superintendent of motive power of the Interborough Rapid Transit Co., New York, has been retained as consulting engineer in connection with the large steam plant which the Buffalo General Electric Co. is building to supplement its hydro-electric energy from Niagara Falls. This new plant will embody many advanced features, including a steam pressure of 275 lb. and an exceptionally high boiler rating.

ENGINEERING AFFAIRS

Progressive Council No. 12, of the Universal Craftsmen Council of Engineers, held its annual entertainment and reception Friday, Mar. 10, at Turnbull Hall, Newark, N. J. An entertainment given by the New York "Bunch" under the direction of Frank Martin, of Jenkins Bros., was followed by dancing.

Detroit Engineering Society—Prof. D. C. Jackson, head of the electrical engineering course at the Massachusetts Institute of Technology will address the Detroit Engineering Society April 7, on the subject "High Power Traction." The society's annual meeting, banquet and installation of officers will take place April 15.

Elizabeth Association No. 14, N. A. S. E., of New Jersey, held its second annual smoker Tuesday, Mar. 14, at Hippodrome Hall. The spacious ballroom was comfortably filled. There were delegations from several sister associations in the vicinity. John Calahan, of Jersey City, was the master of ceremonies. An address by Charles H. Bromley, of "Power," and an entertainment by the New York "Bunch" made the evening an instructive and enjoyable one. Refreshments were served at intervals.

The New York Engineers Protective Society No. 23, N. A. S. E., held its annual dinner and reception on Saturday, Mar. 18, at the West End Restaurant. Fully 150 couples were seated in the main dining hall. The sale of tickets had to be stopped owing to the want of seating space. Between the courses an entertainment was provided by Robert Jones, Monroe Silver and Billy Murray, of Jenkins Bros., and Jack Armour, of "Power.' Dancing followed the dinner. Frank M. Paulsen, Edward Miller and Willian Ott were the committee responsible for this successful event.

NEW PUBLICATIONS

FORD METHODS AND THE FORD SHOPS. By Horace Lucien Arnold and Fay Leone Faurote. Published by the Engineering Magazine Co., New York City. Size, 7x10 in.; 440 pages. Price, $5.

This book is a reprint of articles that appeared in the "Engineering Magazine," the main part being by Horace L Arnold, and the remainder, completed after Mr. Arnold's death, by Mr. Faurote.

Opening with a chapter on the characteristics of Henry Ford and the beginning of the Ford Motor Co., the book

takes up the various departments in detail and gives a wealth of information concerning methods, machines and time required. Practically every problem of shop management seems to be contained in this plant and is so recorded in this book that no one responsible for production can fail to absorb many valuable ideas from it. The questions of hiring and firing, of the health of employees, of the use of unskilled workers, together with the forms employed, are all considered. The methods of both machine shop and foundry are illustrated. The sequence of operation, the time required, the shop layout that makes it possible and much else of interest are given. The chapter on inspection and assembling is of particular value, for inspection is thorough in order to prevent unnecessary machine work being done on imperfect parts. The reduction of time for assembling is shown in considerable detail. Minute details of the motor assembly are given, 84 operations being mentioned, with the men required and the number of seconds for each. Many of the machining operations are also given in detail, both as to sequence and time required; these data should be of service in many shops, even on other lines of work. Crankshafts, pistons, commutators, bushings, gasoline tanks, radiators, etc., are taken up in similar detail.

There is so little specific information available on modern foundry methods and costs that the chapter on this subject should be especially interesting. The size of the foundry alone at once attracts attention—with 1,450 men, melting 192 tons of iron, handling 1,906 tons of sand and pouring 40,450 pieces of an average weight of 8.9 lb. per day. Painting and varnishing of bodies are also treated in detail as to methods, output and the time required.

For both study and reference the book is to be commended to shop executives, planners and those who have to do with production.

Recent Court Decisions

Digested by A. L. H. STREET

Disposal of Waste Steam—A city exercising charter authority to operate a municipal light and power plant has implied authority to utilize waste steam by carrying it through a main to a city building for heating purposes and incidentally furnish steam to private buildings abutting upon the main, although the city's charter power be insufficient to authorize it to maintain a plant primarily devoted to furnishing steam heat to inhabitants. (Montana Supreme Court, Milligan vs. Miles City, 153 "Pacific Reporter," 276.) In reaching this decision, the court said:

When a city is engaged in operating a municipal plant under an authority granted by the general law, it . . . stands upon the same footing as a private individual or a business corporation similarly situated. . . . Common prudence requires that it anticipate the probable growth of population and increasing future needs; that it take note, from time to time, of changing conditions, and adopt improved devices in order to bring and keep the plant up to the highest degree of efficiency; that it make such disposition of any surplus or byproduct as will promote economy in its operation and gain for the people the greatest possible return for the capital invested. . . . To say that a city may not turn the waste or exhaust steam from its electric-light plant to profitable use is to say that, though the Legislature has empowered it to install and operate a light plant, it has withheld from it power to operate it upon intelligent and economic principles.

Classified Ads

Positions Wanted
Positions Open
Civil Service Work
Employment Agencies
Labor Bureaus
Business Opportunities
For Sale
Wanted
Agents and Salesmen
Contract Work
Miscellaneous
Educational
Books
Proposals

RATES: Positions Wanted, 3 cents a word, minimum charge 50 cents an insertion, payable in advance. Other advertisements, 5 cents a word, minimum charge $1.00. Count 4 words for blind address care of our New York or Chicago offices. Advertisements for bids $3.60 an inch.

ANSWERS addressed to us at 10th Ave. and 36th St., New York or 1144 Monadnock Block, Chicago will be forwarded without charge (excepting circulars or similar literature).

IMPORTANT: Original letters of recommendation or other papers of value should not be enclosed to unknown correspondents—send copies. Advertisers' names will not be furnished under any circumstances. Copy received until 10 A.M. Tuesday for following Tuesday's issue. P

POSITIONS OPEN

Illinois

LARGE CENTRAL-STATION COMPANY in Middle West offering excellent opportunities along engineering and commercial lines is seeking applicants in its drafting room on electrical construction of switchboards and general layout of central and sub-station design in connection with installations of large turbo-generators, synchronous converters and transformers; prefer applicants who have completed four years' electrical or engineering course, but men who have had one or two years of college training supplemented by additional study and experience since leaving school may qualify; salary ranges from $70 to $90 per month, depending entirely upon the qualifications of applicants; men who have had training with this company in the drafting department are later transferred to positions in the testing department, and those who wish to seek commercial work are given an opportunity to enter into new business fields; in replying, please give complete information as to age, qualifications and experience and minimum salary considered. Address replies to P752—Power, Chicago.

Missouri

GRADUATE MECHANICAL ENGINEER, thoroughly familiar with stoker business; state age, experience and salary expected; location, Chicago and St. Louis. P754—Power, Chicago.

New York

CHIEF ELECTRICIAN wanted by Long Island City factory having 4,000-hp. installation; must have good electrical education and references as to past work and character; steady work and desirable position for right man. Apply to L. C. Reynolds, General Vehicle Co., Inc., Long Island City, N. Y.

IF YOU ARE a manufacturers' agent, handling a limited line and want to add some boiler room equipment—not specialties—in Chicago territory, write. P757—Power.

Ohio

ENGINEER—Wanted, a man with Ohio license to work in power plant; one month on day shift, next month on night shift, alternating each month; when on day shift will fire when chief is on duty, otherwise will have charge of plant; salary, $90 per month. P755—Power, Chicago.

Pennsylvania

DETAIL DRAFTSMEN wanted; one experienced in air-compressor work; also one experienced in oil and gas engines. Address P739—Power, giving references; state age and salary wanted.

GAS ENGINEER, to operate a producer-gas power plant; a man familiar with double-acting horizontal engines preferred; state age, experience, salary expected; location eastern Pennsylvania. P744—Power.

SEVERAL FIRST-CLASS DRAFTSMEN wanted at once, of general mill and blast furnace experience; state age, experience, present salary and salary wanted in first letter; also when available; central location, Pittsburgh. P687—Power.

SEVERAL DRAFTSMEN wanted at once, experienced in power plant and general piping work; state age, experience, present salary and salary wanted in first letter; also when available; central location, Pittsburgh. P688—Power.

Civil-Service Opportunities

Competitive examinations for the civil-service positions named below will be held on or up to the dates given.

Write to United States Civil Service Commission, Washington, D. C., for information on the following:

NATURAL-GAS ENGINEER (Male)—$1,800-$2,500; examination Apr. 4; for vacancy in Bureau of Mines, Dept. of Interior, for service in the field; write for Circular No. 341 and Application Form No. 2118.

MECHANICAL AND ELECTRICAL INSPECTOR (Male)—$6.72 per diem; examination Apr. 19; for vacancy in Navy Department at any navy yard; write for Circular No. 396 and Application Form No. 1312.

ELECTRICAL DRAFTSMAN (Male)—$5.04 per diem; examination Apr. 25; for vacancy in the Bureau of Steam Engineering, Navy Dept., Washington, D. C.; write for Circular No. 424 and Application Form No. 1312.

Employment Agencies

CORRESPONDENT

THE UNDERSIGNED plans and conducts correspondence for positions in technical, manufacturing and professional lines; $2500 to $15,000 men exclusively; complete privacy assured; no commission charged—only service fee and postage. Send name and address only, in confidence, for prefatory details. R. W. Bixby (established 1910), P1 Niagara Square, Buffalo, N. Y.

POSITIONS WANTED

Connecticut

CHIEF ENGINEER open for position; 20 years' experience in large plants; highest efficiency assured; strictly temperate; best of reference. PW746—Power.

New York

DRAFTING, computing, estimating, heating, ventilating, power, technical graduate, fifteen years' experience; nine years sewer design; married, references. PW756—Power.

POWER-PLANT OPERATING ENGINEER or assistant; licensed man; experienced in the care and operation of engines, boilers and auxiliary equipment; immediately available; location immaterial. PW678—Power.

ERECTING AND MAINTENANCE ENGINEER, 19 years' practical experience, desires position in charge of installing and upkeep of electrical and general industrial plant equipment; 44 years old; married. PW747—Power.

OPEN FOR ENGAGEMENT as mechanical superintendent, master mechanic, salesman or representative; mechanical engineer, 38 years old, qualified in executive matters; 12 years experience with management of steam, gas, oil and electrical installations connected with power, mining and milling work; long residence in Latin-American countries; fluent Spanish. Address "Mechanical," PW758—Power.

WANTED

MANUFACTURER wants either patented or patentable ideas on boiler and engine room specialties; cash or royalty basis. W676—Power.

AGENTS AND SALESMEN

HIGH-GRADE STEAM SPECIALTY SALESMAN, five years' experience with present firm, seeks connection with reliable firm; Philadelphia territory preferred. W750—Power.

AGENTS handling engine and boiler room specialties, in every section, for side line, paying large commissions. Give experience, lines carried and territory covered. W390—Power.

WELL-VERSED boiler-room and combustion men or established engineering agencies to sell mechanical stokers on a liberal commission basis; we manufacture three distinct types to meet all requirements; natural and forced draft. W749—Power, Chicago.

ENERGETIC MEN wanted to sell material making brick boiler settings air-tight; big field as the product fills a long-felt need in boiler room; see advertisement page 93, this issue. The Excello Manufacturing Co., Cleveland, Ohio.

HAVE YOU SUCCESSFULLY SOLD a steam specialty? You can make a profitable connection with an old-established line which sells to power plants everywhere; extensively advertised—unusually liberal contract. W731—Power, Chicago.

AGENTS on commission to sell the new and successful Duplex Return Steam Trap; join a rapidly growing organization. Address American Duplex Steam Trap Co., 413 Moffat Block, Detroit, Mich.

AGENTS on commission to sell our Shaking Grates; we will install grates on trial or put in on test at our expense with any grate made. Address Armstrong Mfg. Co., Springfield, Ohio.

MISCELLANEOUS

PATENT ATTORNEYS

PATENTS. C. L. Parker, patent attorney, formerly member Examining Corps, U. S. Patent Office, McGill Bldg., Washington, D. C. Inventor's handbook sent upon request.

IS YOUR INVENTION VALUABLE? Ask A. P. Connor, electrical, mechanical engineer (ex-chief electrical engineer for New York). Patent attorney. Lawyer. Carroll St., S. E., Washington, D. C.

For Sale

Second Hand Equipment

Rates: Less than 4 insertions 75 cents per line—4 to 11 insertions 70 cents per line—12 or more insertions 65 cents per line

Equipment Wanted items appear at the end of this list.

ADVERTISERS' NAMES are abbreviated in most of these items. Complete names and addresses are as follows:

GRISWOLD Manufacturing Co., Erie, Pa.

POWER Mchy. Exchange, 14 Morris St., Jersey City, N. J.

SCHRAGE, H. A., Village Clerk, New Bremen, Ohio.—The equipment advertised is in good condition and ready for testing at any time.

AIR COMPRESSORS

1 Ingersoll-Sergeant Drill Co.'s; cy. 12x12.—SCHRAGE.

BOILERS

1—54"x12' Erie horiz. return tubular, butt strapped, 125 lb.—L. F. Seyferts Sons, Inc., 437 N. 3d St., Phila., Pa.

Two 250 H.P. Babcock & Wilcox water tube, 150 lb. pressure, 4 years' service; good as new, $2000 for both. Also seven 150 H.P. return tubular, butt strapped, 125 lb. pressure, fine condition, $450 each.—POWER MCHRY.

Brownell high-pressure; dia. 72"x17' 8" length.—SCHRAGE.

1 80-hp. horizontal, new flues.—New York Metallic Bedstead Co., 184 Pacific Ave., Jersey City, N. J.

CHAIN DRIVE

1 piece Reynolds silent chain, 1½" pitch, 6" wide, 15' long; 2 sprockets 8.16" and 42.98" in dia.—GRISWOLD.

ENGINES, GAS

Westinghouse vertical, 40 hp., now running; in best possible condition. Selling because of purchase of a larger unit. Delivery immediately.—The Acklin Stamping Co., Toledo, O.

ENGINES, STEAM

18x36 Allis-Chalmers Corliss, latest type, heavy duty frame; practically new, $800.—POWER MCHY.

Allis Corliss 18x36 with rolling mill type bed; belt flywheel 12'x30"; first class condition.—P. O. Box 1537, Phila., Pa.

American Ball engine, 160 hp., 16"x14", 250 r.p.m. with belt wheel 72"x15", new, was never set on foundation. FS753—POWER.

300 H.P. Corliss, in operation only six months, excellent condition. Immediate delivery. Full particulars on inquiry.—Militaire Motor Vehicle Co., Buffalo, N. Y.

GENERATORS

We have a customer who has installed larger equipment and is anxious to dispose of a Sturtevant Generator, 200 kw., 500 volts.—B. F. Sturtevant Co., Hyde Park, Boston, Mass.

GENERATING UNITS

Engine and Generator—One Hamilton Corliss 18x36x42" horizontal cross compound engine with 14x16" cast iron flywheel; direct connected to Westinghouse 580-kw. generator, 440 v., 761 amp., 3-phase, 25-cycle, 107 r.p.m. Generator is revolving field; the Exciter is steam driven. No Switchboard with this outfit. Engine now running condensing. All of the equipment, such as pumps and piping, is in connection with the Engine. The condenser is of the surface type. 140 lb. steam pressure used. Floor space 21 ft. 8 inches wide—28 ft. long over all. Equipment has been in operation five years and can be seen in operation at our Cedar Rapids Mill. For price and full information address National Oats Co., St. Louis, Mo.

Two 75 K.W. Ridgeway direct connected generators and engines, 230 V.; practically new; $800 each.—POWER MCHY.

1 Ridgway engine, 14x14, 124 hp., and 1 Ridgway dynamo, 75 kw., 250 volts; both practically new and form a unit.—The Ford Lumber & Mfg. Co., Winchester, Ky.

1—17x24 Erie City 4-valve automatic engine direct connected to 150 K.W., 25 cy. A.C. generator.—GRISWOLD.

HEATERS, FEED WATER

1 Webster Star vacuum purifier and heater, Class C, rated 300 H.P.—GRISWOLD.

PUMPS

2 steam (John McGowan Co.), No. 14049, duplex comp., cy. 7—12x7x10.—SCHRAGE.

WANTED

2—250-hp. water-tube boilers for not less than 150 lb. steam pressure; must be able to stand casualty inspection. State price.—Chambersburg Ice & Cold Storage Co., Chambersburg, Penn.

FOR SALE

Bids received until Apr. 20, 1916.

Purchase of Winches

Boston, Mass., March 28, 1916.

Sealed bids or proposals for the purchase of any or all of the following surplus freight handling winches will be received by the Directors of the Port of Boston at their offices at 40 Central Street, Boston, Mass., until 12 o'clock noon, April 20th, 1916, when bids will be publicly opened.

The Directors are not obligated to accept any offer that does not represent the fair market value of the winches.

Proposals shall be made upon blank forms which may be obtained from the Directors and should be accompanied by a certified check for ten per cent. of the amount of proposal.

10 Double winches, numbered 1 to 10 inclusive,

8 Single winches, numbered 11 to 18 inclusive.

Each double winch is equipped with 2 drums and 2 winch heads and each single winch is equipped with 1 drum and 2 winch heads.

These winches were manufactured by the Maine Electric Company of Portland, Maine, and delivered to the Directors in 1913. These winches are equipped with 250 volt direct current, General Electric motors, having a duty of 3,000 lbs. at a speed of 250 feet per minute on the drums. These winches are practically new, some not having been used. They are suitable for use as cargo hoists on piers and also suitable for use on construction, hauling coal, ores or for other similar purposes. The winches may be examined at Commonwealth Pier 5, South Boston. Further particulars may be obtained upon application.

EDWARD F. McSWEENEY (Chairman), JOSEPH A. CONRY, LOMBARD WILLIAMS, Directors of the Port of Boston. ROBERT E. BARRETT, Acting Chief Engineer.